

**LOWER DUWAMISH WATERWAY BASELINE SURFACE
SEDIMENT COLLECTION AND CHEMICAL ANALYSES
- QUALITY ASSURANCE PROJECT PLAN**

DRAFT FINAL

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Lower Duwamish Waterway Group

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TITLE AND APPROVAL PAGE
SURFACE SEDIMENT COLLECTION AND CHEMICAL ANALYSES
QUALITY ASSURANCE PROJECT PLAN

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Acronyms

%RSD	percent relative standard deviation
95UCL	95% upper confidence limit for the mean
<u>ac</u>	<u>acre</u>
ALS	ALS Environmental-Kelso
AOC	Administrative Order on Consent
ARI	Analytical Resources, Inc.
Axys	Axys Analytical Services Ltd.
CFR	Code of Federal Regulations
City	City of Seattle
CLT	Central Limit Theorem
COC	contaminant of concern
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CRM	certified reference material
CTO	chemothermal oxidation
CV-AFS	cold vapor-atomic fluorescence spectrometry
DCM	dichloromethane
DGPS	differential global positioning system
DL	detection limit
DQI	data quality indicator
DQO	data quality objective
dw	dry weight
Ecology	Washington State Department of Ecology
EDL	estimated detection limit
EIM	Environmental Information Management
ENR	enhanced natural recovery
EPA	US Environmental Protection Agency

FC	field coordinator
GC/ECD	gas chromatography/electron capture detection
GC/MS	gas chromatography/mass spectrometry
GPC	gel permeation chromatography
GPS	global positioning system
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HpCDD	heptachlorodibenzo- <i>p</i> -dioxin
HpCDF	heptachlorodibenzofuran
HRGC/HRMS	high-resolution gas chromatography/high-resolution mass spectrometry
HSP	health and safety plan
HxCDD	hexachlorodibenzo- <i>p</i> -dioxin
HxCDF	hexachlorodibenzofuran
ICP-MS	inductively coupled plasma-mass spectrometry
ID	identification
IR	infrared spectroscopy
ISO	International Organization for Standardization
LCS	laboratory control sample
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LLOQ	lower limit of quantitation
LMCL	lower method calibration limit
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MDL	method detection limit
MHHW	mean higher high water
MLLW	mean lower low water
MNR	monitored natural recovery
MS	matrix spike
MSD	matrix spike duplicate

NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
OCDD	octachlorodibenzo- <i>p</i> -dioxin
OCDF	octachlorodibenzofuran
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PE	polyethylene
PeCDD	pentachlorodibenzo- <i>p</i> -dioxin
PeCDF	pentachlorodibenzofuran
PM	project manager
PPE	personal protective equipment
PRC	performance reference compound
PSEP	Puget Sound Estuary Program
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RAL	remedial action objective
RAO	remedial action objective
RI/FS	remedial investigation/feasibility study
RL	reporting limit
RM	river mile
RME	relative margin of error
ROD	Record of Decision
RPD	relative percent difference
SCO	sediment cleanup objective

SD	storm drain
SDG	sample delivery group
SIM	selected ion monitoring
SM	Standard Methods
SMS	Washington State Sediment Management Standards
SOP	standard operating procedure
SoundEarth	SoundEarth Strategies, Inc.
SPU	Seattle Public Utilities
SRM	standard reference material
SVOC	semivolatile organic compound
SWAC	spatially weighted average concentration
SWPPP	stormwater pollution prevention plan
T-107	Terminal 107
TCDD	tetrachlorodibenzo- <i>p</i> -dioxin
TCDF	tetrachlorodibenzofuran
TEF	toxic equivalency factor
TEQ	toxic equivalent
TM	task manager
TOC	total organic carbon
UCT-KED	universal cell technology-kinetic energy discrimination
WAC	Washington Administrative Code
Windward	Windward Environmental LLC
ww	wet weight

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1 Introduction

This quality assurance project plan (QAPP) describes the quality assurance (QA) objectives, methods, and procedures for collecting surface sediment¹ from the Lower Duwamish Waterway (LDW) for chemical analyses, with a subset of the samples also being used for an *ex situ* porewater investigation for polychlorinated biphenyls (PCBs). As described in the *Pre-Design Studies Work Plan* (Windward and Integral 2017b), hereafter referred to as the Work Plan, these data are being collected and analyzed to address the third amendment to the Administrative Order on Consent (AOC) (EPA 2016c).

The Work Plan presents the data quality objectives (DQOs) and conceptual study design for the surface sediment collection and associated analyses (Windward and Integral 2017b). This QAPP includes these DQOs and presents the detailed study design, including specifics on project organization, field data collection, laboratory analyses, and data management.

US Environmental Protection Agency (EPA) guidance for QAPPs was followed in preparing this document (EPA 2002). The remainder of this QAPP is organized into the following sections:

- u Section 2 – Project Objectives and Description
- u Section 3 – Project Organization and Responsibilities
- u Section 4 – Data Generation and Acquisition
- u Section 5 – Assessment and Oversight
- u Section 6 – Data Validation and Usability
- u Section 7 – References

Appendix A to this QAPP is a health and safety plan (HSP) designed to protect on-site personnel from physical, chemical, and other hazards posed by the field sampling effort. Field collection and analysis forms are included as Appendix B. Laboratory methods and the associated reporting limits (RLs) are provided in Appendix C. Appendix D presents standard operating procedures (SOPs) for the *ex situ* porewater investigation and subsampling sediment. Appendix E contains reconnaissance survey notes.

¹ Bank samples are also being collected; they are included in the general discussion of surface sediment except where specifically noted otherwise.

2 Project Objectives and Description

EPA issued a Record of Decision (ROD) for the LDW Superfund site on November 21, 2014 (EPA 2014b). The ROD describes the selected sediment remedy for the LDW, and identifies monitoring activities, including baseline sampling of LDW media for comparison to post-remedial data. This QAPP addresses baseline sampling of surface sediment as well as an *ex situ* assessment of PCBs in porewater.

2.1 DATA QUALITY OBJECTIVES

Per the third amendment to the AOC (EPA 2016c), the collection of surface sediment data is required to characterize baseline conditions prior to implementation of the sediment remedy, and to support source control efforts. As described in the Work Plan (Windward and Integral 2017b), which includes the porewater addendum (Windward and Integral 2017a), ~~nine-10~~ DQOs have been identified for the collection and analysis of baseline surface sediment samples, including an *ex situ* porewater investigation for PCBs, as well as source-related samples. These DQOs are presented in Sections 2.1.1 through and 2.1.3.2 for 0–10-cm and 0–45-cm sediment samples, respectively. ~~The DQO for the *ex situ* porewater investigation is presented with the DQOs for the 0–10-cm samples.~~

~~In addition, per the third amendment to the AOC (EPA 2016c), near outfall sediment and bank samples will be collected and analyzed to support the Washington State Department of Ecology's (Ecology's) source control efforts for the LDW (Section 2.1.3).~~

2.1.1 Surface sediment (0–10-cm) samples

Surface sediment samples (0–10-cm) will be collected to establish site-wide baseline concentrations, to determine location-specific concentrations in monitored natural recovery (MNR) areas, ~~and~~ to collect additional PCBs porewater data through an *ex situ* investigation, and to collect source-related data near outfalls and from banks. ~~Five~~ Six DQOs have been identified for 0–10-cm sediments; these DQOs are summarized in Table 2-1.

Table 2-1. DQOs for surface sediment samples (0–10 cm)

DQO Step	DQO 1	DQO 2	DQO 3	DQO 4	DQO 5	DQO 6
STEP 1: State the problem.	A synoptic site-wide sediment dataset is needed to assess the baseline condition prior to implementation of the sediment remedy.		<u>Because surface sediment concentrations are likely to change over time, additional sediment concentration data from MNR areas^a are needed for a qualitative check on natural recovery^b prior to the sediment remedy to compare to RAO 3 sediment (benthic invertebrate) cleanup levels.</u>		Additional co-located bulk sediment-porewater data are needed over the range of PCB concentrations in MNR/ENR areas to assess the potential effects of reduced sediment concentrations on biota exposure and tissue concentrations. <u>If the relationship is predictive, porewater data may not be needed to predict whether reductions in sediment concentrations will reduce tissue concentrations in biota.</u>	<u>Additional bank and near-outfall sediment data are needed to fill data gaps from earlier source control sampling efforts.</u>
STEP 2: Identify the goals of the study.	Establish baseline, site-wide 95UCL concentrations of RAOs 1, 2, and 4 risk drivers.	Establish a baseline, site-wide SWAC to serve as the foundation for assessing temporal trends for RAOs 1, 2, and 4 risk drivers.	Compare (on a point-by-point basis) concentrations in baseline samples collected from within MNR areas to RAO 3 (benthic) cleanup levels^a <u>levels.^b</u>	Collect site-specific sediment data to support future site-wide trend assessment and comparison to predicted concentrations in MNR areas^a <u>areas.^b</u>	Investigate baseline porewater <u>PCB</u> concentrations in MNR/ENR areas for PCBs to assess the predictability of the relationship between porewater and sediment PCB congener concentrations.	<u>Collect bank and near-outfall sediment data to assist Ecology in source control efforts.</u>
STEP 3: Identify the information inputs.	Existing sediment data from the LDW and associated statistics (e.g., variance) were used to determine the appropriate sample sizes needed to achieve the <u>desirable statistical power precision for the site-wide</u>		Existing sediment data were used to identify locations of SMS exceedances in preliminary MNR areas in ROD Figure 18 (EPA 2014b).		Existing sediment data and ROD Figure 18 (EPA 2014b) were used to estimate the range of PCB concentrations in preliminary MNR/ENR areas.	<u>Existing source data were reviewed in consultation with EPA and Ecology to determine where additional data are needed.</u>

DQO Step	DQO 1	DQO 2	DQO 3	DQO 4	DQO 5	DQO 6
	mean of the sampling design necessary to establish baseline and evaluate trends.					
STEP 4: Define the boundaries of the study.	The boundary of the study has been defined by the ROD. Preliminary MNR and ENR areas were established in Figure 18 of the ROD (EPA 2014b).					<u>The boundary of the study has been defined by the ROD.</u>
STEP 5: Develop the analytical approach.	The 95UCL will be calculated using the best-fit statistical distribution for the data.	The site-wide SWAC will be estimated from the arithmetic mean of the composite samples. Each composite sample represents approximately the same-sized spatial area, allowing for a simplified estimate of the SWAC.	Individual sample results from 20 locations (10 random and 10 reoccupied RI locations) will be compared to RAO 3 cleanup levels on a point-by-point basis.	Data from the 10 reoccupied RI locations will be used on a point-by-point basis over time to assess changes in surface sediment quality.	Paired sediment-porewater data will be combined with existing paired sediment-porewater data from the LDW to evaluate the regression relationships.	<u>Data from 24 near-outfall sediment locations, as well as from 6 banks, will be collected and submitted to Ecology to assist in source control efforts.</u>
STEP 6: Specify performance or acceptance criteria.	Performance or acceptance criteria are described in Section 4.6, including field QC samples and laboratory QC samples. DQIs for laboratory analyses (i.e., PARCCS) will be met, as described in Section 4.6.					

DQO Step	DQO 1	DQO 2	DQO 3	DQO 4	DQO 5	DQO 6
STEP 7: Develop the detailed plan for obtaining data.	A spatially balanced <u>random</u> sampling design has been developed to collect 168 samples distributed throughout the study boundary. <u>One random sampling location will be selected. The 168 samples will come from 16 non-random (i.e., reoccupied locations) and 152 random locations</u> within <u>each of 168</u> sampling grid cells of approximately equal area. A total of 24 composite samples will be constructed, each composed of the grab samples from 7 neighboring grid cells. This design <u>will avoid spatially clustering of samples, which will improve statistical efficiency. The non-random sampling will allow for the calculation of unbiased estimates of the site-wide mean and standard error. The arithmetic mean of the observations is will also be a SWAC, because equal spatial weighting is intrinsic to the sample design.</u>	<u>Ten The 10 non-random (i.e., reoccupied RI) locations were selected from the set of RI/FS locations in preliminary MNR areas with sediment concentrations > benthic SCO were selected, plus. The other 10 random locations were selected at random from among the subset of the 168 152 random samples for DQOs 1 and 2 that fall within MNR areas.</u>	<u>Data from the 10 non-random (i.e., reoccupied RI) locations that were selected from MNR areas with sediment concentrations > benthic SCO will be re-sampled during future compared to past and potentially to future e-monitoring events data to assess trends changes over time.</u>	<u>Sixteen Twenty</u> candidate locations were selected, <u>that including</u> the 10 <u>non-random reoccupied RI</u> locations used in DQO 3, plus an additional <u>6-10</u> reoccupied locations targeted to capture a wider range of PCB concentrations <u>in MNR/ENR areas</u> . All <u>20 16</u> bulk sediment samples will be analyzed for PCBs and organic carbon. <u>Ten of Among</u> the samples with the desired range of PCB concentrations in sediment, <u>10</u> will be selected for <i>ex situ</i> porewater testing and PCB congener analysis.	<u>The 24 near-outfall sediment samples were selected to fill data gaps near outfalls without existing data nearby. At the 6 bank areas, a total of 11 locations will be sampled. One sample will be collected from each bank location unless conditions suggest the need for a vertical transect sample(s).</u>	

- a It is acknowledged that the remedial boundaries and technology assignments portrayed in ROD Figure 18, titled *Selected remedy*, are likely to change following design. Thus, any reference to MNR areas refers to preliminary area designations.
- b More intensive characterization relative to RAO 3 will be conducted during design, compliance monitoring, and long-term monitoring. Concentrations are not expected to meet natural recovery predictions during baseline sampling because the projections are for 10 years post-remedy. In addition, additional data will be collected during remedial design to support design decisions, such as where remedial technologies apply, and to better establish baseline relative to RAO 3 cleanup levels.
- c Assumptions for the composite sample dataset (i.e., normally distributed data and a coefficient of variation of 0.7 or less) result in an RME of 25% or better for the post-remedy mean.

95UCL – 95% upper confidence limit for the mean
DQI – data quality indicator
DQO – data quality objective

MNR – monitored natural recovery
PARCCS – precision, accuracy, representativeness, completeness, comparability, and sensitivity

RI/FS – remedial investigation/feasibility study
ROD – Record of Decision
RME – relative margin of error

Ecology – Washington State Department of Ecology

ENR – enhanced natural recovery

LDW – Lower Duwamish Waterway

PCB – polychlorinated biphenyl

QC – quality control

RAO – remedial action objective

SCO – sediment cleanup objective

SMS – Washington State Sediment Management Standards

SWAC – spatially weighted average concentration

2.1.1.1 **Baseline surface (composite samples 0–10-cm) sediment for site-wide RAOs**

The DQOs for the establishment of site-wide baseline conditions in 0–10-cm LDW surface sediment samples are as follows:

1. Establish baseline, site-wide 95% upper confidence limit for the mean (95UCL) concentrations of remedial action objectives (RAOs) 1, 2, and 4 risk drivers.²
2. Establish baseline, site-wide spatially weighted average concentration (SWAC) to serve as the foundation for assessing trends from before to after sediment remediation for RAOs 1, 2, and 4 risk drivers.

The baseline surface sediment sample design is tailored to the DQOs above. Specifically, a spatially balanced sampling design has been developed to collect 168 samples distributed throughout the study boundary. The 168 samples will be collected ~~from 16 non-random (i.e., reoccupied remedial investigation [RI] locations) and 152 at one random locations~~ within ~~each~~ sampling grid cell, ~~all of which are~~ of approximately equal area. Once collected, the surface sediment samples from these 168 cells will be combined into 24 composite samples for analysis. Each composite sample will contain seven grab samples.

Baseline concentrations will be established based on the composite sample data collected from a single site-wide sampling event. ~~This s~~Sediment sampling ~~approach~~ can then be repeated over time to generate comparable datasets to assess progress toward cleanup goals, and to assess the effectiveness of the remedy in attaining the site-wide RAOs.

Baseline site-wide concentrations will reflect the combined effects of 1) cleanup actions at approximately 29 ~~acres (ac)~~ of early action areas, 2) ongoing source control, and 3) ongoing natural recovery throughout the LDW. Site-wide SWAC comparisons over time will establish trends in sediment concentrations, while the 95UCL is the ROD compliance metric for surface sediment area-wide cleanup levels (EPA 2014b).

The surface sediment composite samples will be analyzed for the contaminants of concern (COCs) for RAOs 1, 2, and 4 (PCBs, total arsenic, cPAHs, and dioxins/furans) (ROD Table 19) (EPA 2014b) and conventional parameters, including total organic carbon (TOC), black carbon, grain size, and total solids.

2.1.1.2 **Individual 0–10-cm sediment samples**

~~Splits from 20~~Twenty individual samples ~~(a subset of the 168 grab samples described above)~~ will be collected within ~~the~~ preliminary MNR areas ~~shown~~ in ROD Figure 18

² Risk drivers are PCBs, dioxins/furans, carcinogenic polycyclic aromatic hydrocarbons [cPAHs], and arsenic (ROD Table 19, titled *Cleanup levels for PCBs, arsenic, cPAHs, and dioxins/furans in sediment for human health and ecological COCs [RAOs 1, 2, and 4]*). PCBs are the only risk drivers for RAO 4.

(EPA 2014b)³ ~~and will be~~ individually analyzed for RAO 3 COCs to address DQOs 3 and 4:

3. Compare (on a point-by-point basis) concentrations in baseline samples collected from within MNR areas to the (benthic) cleanup levels presented in ROD Table 20⁴ (EPA 2014b).
4. Support the evaluation of site-wide trends and comparison of concentrations to predicted natural recovery in MNR areas.⁵

Ten of the 20 locations⁶ were identified to reoccupy LDW remedial investigation (RI)/feasibility study (FS) surface sediment locations in MNR areas with sediment cleanup objective (SCO)⁷ exceedances (MNR > SCO) based on existing data; ~~these locations are fixed station locations that will be resampled during future monitoring events. The other 10 locations were randomly selected from locations within MNR areas. During long-term monitoring, repeated measurements over time at using a~~ these 10 fixed locations or rotating panel design will support the evaluation of ~~site-wide~~ trends and comparisons with predicted natural recovery in MNR areas. ~~The other 10 locations were randomly selected from locations within MNR areas.~~

~~The samples from these 20 locations constitute a split panel sampling design⁸ for measuring status and observing trends in the MNR areas.~~ Note that these data are not being collected to delineate MNR areas, nor to assess MNR area compliance; data to address those needs will be collected during design and compliance monitoring.

These 20 samples will be analyzed for the target analytes in Table 20 of the ROD (EPA 2014b), and archives will be retained ~~for potential congener analyses, as described in Section 2.1.1.4.~~

³ It is acknowledged that the remedial boundaries and technology assignments portrayed in ROD Figure 18, titled *Selected remedy*, are likely to change following design. Thus, any reference to MNR, enhanced natural recovery (ENR), cap, or dredge areas in this QAPP refers to preliminary area designations.

⁴ ROD Table 20 is titled *Sediment cleanup levels for ecological (benthic invertebrate) COCs for RAO 3*. MNR areas are preliminary because remedial boundaries and technology assignments portrayed in ROD Figure 18 (EPA 2014b), titled *Selected remedy*, are likely to change during remedial design.

⁵ Concentrations are not expected to meet natural recovery predictions during baseline sampling because the projections are for 10 years post-remedy.

⁶ ~~Because these samples also will contribute to the composite design to address DQOs for RAOs 1, 2, and 4 (see Section 4.1.1), the number of fixed locations was restricted to limit bias in the site-wide mean estimate.~~

⁷ SCO is the term used in this sediment QAPP to refer to the benthic numeric cleanup criteria in Washington State Sediment Management Standards (SMS) Chapter 173-204-562. The benthic SCOs are also the cleanup levels for RAO 3 in the ROD.

⁸ ~~In this split panel design, 1 panel has 10 fixed locations that will be revisited during every sampling event; the other panel has 10 locations re-randomized during every sampling event.~~

2.1.1.3 Ex situ porewater samples

The DQO for the collection of PCB porewater data⁹ is as follows:

5. Estimate baseline porewater concentrations in MNR/ENR areas for PCBs. This DQO is primarily intended to help assess the effect of reduced sediment concentrations on biota exposure and tissue concentrations.

In the LDW, PCB porewater data currently are available for 31 locations (Windward and Integral 2017a). In addition to these field data, porewater concentrations can be predicted from sediment concentrations using the two-carbon equilibrium partitioning modelling that has been conducted for the LDW. To address DQO 5, PCB concentrations in sediment and porewater from 10 additional locations will be analyzed to potentially improve the ability to predict PCB concentrations in porewater.

~~Sixteen-Twenty~~candidate-sampling locations have been identified with surface sediment PCB concentrations spanning that represent the range of PCB concentrations in the MNR/ENR areas. These ~~16-20~~ targeted locations include the 10 ~~fixed~~ reoccupied RI locations in MNR areas selected to address DQO 3 (Section 2.1.1.2), and an additional ~~6-10~~ reoccupied RI locations to maximize the likelihood of sampling locations with the targeted range of total PCB concentrations, including six locations with concentrations above 720 µg/kg.^{10,14} ~~to attempt to capture the range of PCB concentrations in MNR/ENR areas.~~

Sediment from the 20 sampling locations will be exposed to passive samplers for ~~1-month~~ 28 days as part of an *ex situ* porewater investigation. Passive samplers will be used to characterize the freely dissolved PCB congener concentrations in porewater.

All ~~16-20~~ sediment samples will be analyzed for PCB Aroclors and TOC; based on these data (in consultation with EPA), 10 samples will be selected for analysis of the passive sampler extracts for PCB congeners. The goal is to have 10 samples with total PCB concentrations (Aroclor sums) distributed across the range of concentrations detected in the 20 samples (potentially up to approximately 2,000 µg/kg dw). The 10 corresponding sediment samples will be analyzed for PCB congeners and black carbon.¹² The remaining ~~six~~ 10 porewater extracts and sediment samples will be archived.

⁹ Porewater data for cPAHs will be discussed in the clam QAPP.

¹⁰ The additional 10 reoccupied RI locations had concentrations as high as 2,154 µg/kg, while the upper limit of the MNR/ENR range is 720 µg/kg (based on the ENR upper limit and assuming 2% TOC). The larger range will increase the likelihood that the actual range of PCB concentrations in samples will be up to 720 µg/kg, and may also be helpful in assessing the relationship between current PCB concentrations in sediment and porewater in MNR/ENR areas.

¹⁴ ~~These 6 locations were selected from the 168 locations identified for DQOs 1 and 2.~~

¹² These 10 sediment samples, along with paired Aroclor-congener results, will be used as described in Section 2.1.1.4.

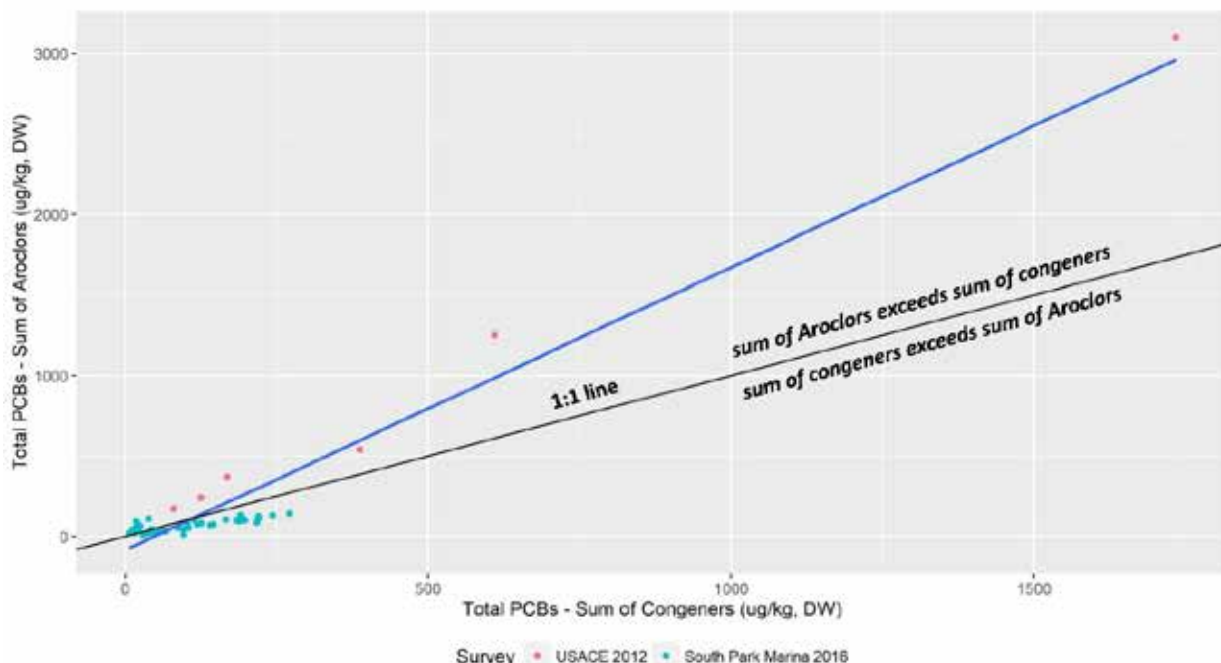
Details regarding the methodology for conducting this *ex situ* investigation (e.g., type of passive sampler) are presented in Section 4.5 of this QAPP.

2.1.1.4 Evaluation of relationship between total PCBs as sum of Aroclors and total PCBs as sum of congeners

The relationship between total PCBs based on the sum of detected congeners versus the sum of detected Aroclors in LDW sediment was also assessed as part of this QAPP, per the Work Plan (Windward and Integral 2017b).

The existing RI/feasibility study (FS) and post-2010 (Task 2) data were reviewed to identify sediment samples with results for both PCB Aroclors and PCB congeners. These data were evaluated to determine if-whether total PCBs calculated using an Aroclor sum and total PCBs calculated using a PCB congener sum appear to be reliably correlated, or whether detectable systematic bias exists for one method to over- or under-estimate the total.

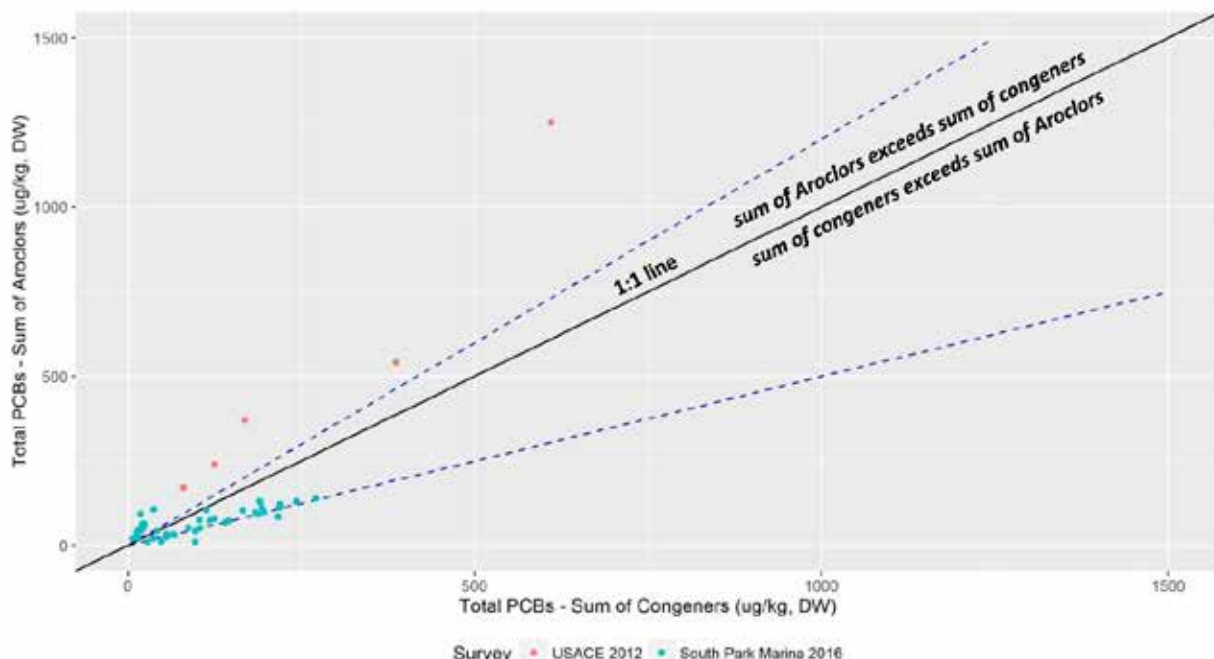
A total of 51 existing sediment samples from 21 unique locations are available from within the LDW with detected PCB Aroclors and congeners. These data are from two sampling events: an LDW-wide sediment characterization conducted for the US Army Corps of Engineers (USACE) in 2012 (HDR et al. 2013), and a focused investigation of the South Park Marina conducted by the Intelligence Group in 2016 (TIG 2016). The USACE characterization included the collection of sediment cores from six locations in the LDW. Samples were analyzed from the 0–2-ft depth at four locations, and the 6.5–8.5- and 8–10-ft depths at one location each. The South Park Marina samples were collected from 16 locations in the vicinity of the marina. Three depth intervals were analyzed at each location: a surface sediment sample (0–10 cm) and two subsurface sediment samples (0.3–3.3 and 3.3–6.6 ft). Data from these two studies were evaluated to assess the relationship between the two PCB sums. When the relationship was viewed on a linear scale (Figure 2-1), the correlation coefficient was large (Pearson's $r = 0.97$, $p < 0.001$), indicating a strong correlation between the two sums. However, visual inspection of the graphic suggests that two different trends may be present or that influential data points are present. The correlation is strongly influenced by two samples with PCB concentrations greater than 600 µg/kg dry weight (dw). Most of the available PCB data were less than 300 µg/kg dw. At the highest concentrations (> 600 µg/kg dw) and the lowest concentrations (< 20 µg/kg dw), the sum of Aroclors tends to overestimate the sum of the congeners.



The black line is the 1:1 line, indicating perfect agreement between the two sums; the blue line is the best-fit regression line fit to all the data on the linear scale.

Figure 2-1. Relationship between total PCBs as sum of Aroclors and as sum of congeners, linear-scaled axes

To assess how well results from the two methods match one another, the paired sediment data were plotted relative to the 1:1 line (indicating perfect agreement), the analytical variance around the 1:1 line was estimated based on the accuracy limits for the PCB Aroclor analysis of 50 to 120% (Figure 2-2). All of the data points above the 1:1 line, for which the Aroclor sums over-estimate the congener sums, were outside of the analytical variance. Most (82%) of the data points below the 1:1 line, for which the Aroclor sums under-estimate the congener sums, were within the analytical variance. These results suggest that it is unlikely that the use of Aroclor data would result in an underestimation of total PCBs.



The black line is the 1:1 line, indicating perfect agreement between the two sums; the dashed lines represent the acceptable analytical variance around the 1:1 line. One sample with PCB concentration greater than 1,500 $\mu\text{g/kg dw}$ is not shown on this plot.

Figure 2-2. Relationship between total PCBs as sum of Aroclors and as sum of congeners, relative to analytical variance

~~The existing data provide a significant relationship between total PCBs calculated as the sum of Aroclors and the sum of congeners. The sum of Aroclors both overestimates and underestimates the sum of congeners. The data with Aroclor sums that are less than the congener sums are predominately within the estimated analytical variance around the 1:1 line.~~

~~Additional~~ Sediment data from the 10 locations selected for the *ex situ* porewater investigation (Section 2.1.1.3) will be added to the Aroclor/congener sediment dataset when these data are available, and the relationship will be re-evaluated with and without the existing data. Additional data may be collected to better define this relationship in the future. These data will be collected over time for a variety of purposes (including those associated with remediation efforts), and the relationship will be re-evaluated with respect to the questions posed at that time. The relationship will then be re-evaluated in the data evaluation report to determine if any of the archived samples should be analyzed for PCB congeners.

2.1.23 Targeted source-related sampling

In addition to the baseline sediment sampling, targeted source-related ~~sediment and bank~~ sampling will be conducted to address the following DQO: These samples will be intended to “h

6. Help Ecology assess the sufficiency of contaminant source control through additional near-outfall sediment sampling and bank sampling” (EPA 2016c).

2.1.23.1 Near-outfall surface sediment sampling

To assist Ecology in its source evaluation for the LDW, surface sediment (0–10 cm)¹³ will be collected near the outfalls recommended by Leidos (2014a)¹⁴ that also meet the screening criteria developed in the Work Plan (Windward and Integral 2017b). Specifically, an attempt will be made to sample sediment near outfalls that fit the following conditions:

- u Do not have sufficient data within approximately 50 ft (outfalls with diameters less than or equal to 24 in.) or approximately 100 ft (outfalls with diameters greater than 24 in.)
- u Are not near a cleanup site under an Agreed Order or expected to be
- u Are expected to be sampleable based on information from Leidos (SAIC 2011; Leidos 2014a) and information gathered during a field reconnaissance effort performed on September 1 and 25, 2017 (see Appendix E)

As discussed in Section 4.1.2.1 of this QAPP, as a result of this screen, a total of 24 source-related surface sediment samples will be collected near 22 outfalls. Near outfalls with no additional nearby sediment data, two samples will be collected. Near outfalls with some existing nearby sediment data, one sample will be collected. Where feasible, samples will be collected within 50 ft of outfalls with diameters less than or equal to 24 in., and within 100 ft of outfalls with diameters greater than 24 in.

Sediment samples will be analyzed for the analytes listed in ROD Table 20 (EPA 2014b). A subset of samples will also be analyzed for dioxins/furans based on existing

¹³ During its 2011 outfall surface sediment sampling, SAIC collected samples from a depth of 0–10 cm where possible (sample depths ranged from 0–3 to 0–10 cm) (SAIC 2011). Samples from a depth of 0–10 cm are consistent with the SAIC 2011 sampling effort and with other surface sediment samples described in this QAPP. If a 0–10-cm sample cannot be collected from a given location, samples from a depth of less than 10 cm will be retained for analysis (see Section 4.2.2.2).

¹⁴ Leidos (2014a) recommended sediment sampling near outfalls that met the following criteria: 1) the outfall was active or presumed active, 2) it was not adjacent to a cleanup site, and 3) existing post-1999 surface sediment data were not sufficient (i.e., two sediment samples collected within 50 to 100 ft from 2000 to present).

sediment data (see Section 4.1.2.1). In addition, an archive jar will be filled for samples collected near all other outfalls.

2.1.23.2 Bank soil sampling

Uncharacterized bank soils (0–10 cm)¹⁵ between +4 and +12 ft mean lower low water (MLLW)¹⁶ will also be sampled to assist Ecology in its source evaluation for the LDW, if the bank meets all of the following criteria:

- u Bank soils are exposed and potentially erodible (i.e., constructed armoring is absent or of poor integrity).
- u The bank is not adjacent to an upland cleanup site under or expected to be under an Agreed Order or an early action.
- u Insufficient bank soil data exist.
- u The bank soil can be sampled.

Overwater structures prevent characterization in some bank areas. Such areas will be addressed in remedial design.

- u After eliminating the bank areas that did not meet these criteria, the remaining uncharacterized exposed bank areas were assessed in a field reconnaissance survey on August 31 and September 1, 2017. The goal of this survey was to determine whether the locations appear to be sampleable based on the presence and condition of overwater structures (which can create unsafe sampling conditions) and the presence and integrity of armoring. Based on this field reconnaissance (see Appendix E), six banks appear to be sampleable; see Section 4.1.2.2 for details.

For each of the six banks, ~~composite-discrete~~ samples will be ~~collected~~~~reated~~. The number of ~~composite-discrete~~ samples per bank will range from one to ~~three~~~~eight~~, depending on the length of the bank. Samples will be analyzed for the analytes listed in ROD Table 20 (EPA 2014b). Samples from Bank Area 2 will also be analyzed for dioxins/furans, and an archive jar will be filled for all bank sample locations (see Section 4.1.2.2).~~Samples will also be analyzed for dioxins/furans, if the dioxin/furan TEQ is greater than the RAL in nearby sediment samples.¹⁷ dioxins/furans.~~

¹⁵ In 2011, Hart Crowser collected bank samples for Ecology from a depth of 1–10 cm at 7 of the 8 bank sampling locations (Hart Crowser 2012). To be generally consistent with the Hart Crowser samples, bank samples for this effort will be collected from a depth of 0–10 cm.

¹⁶ This elevation is approximately equal to mean higher high water (MHHW). The National Oceanic and Atmospheric Administration (NOAA) reports MHHW at the Seattle station (Elliott Bay) as +11.36 ft MLLW (NOAA 2013).

¹⁷ ~~Bank samples will be archived for potential dioxin/furan analysis pending the analysis of adjacent sediment samples, as described in Section 4.4.2.~~

2.1.32 Intertidal surface sediment (0–45-cm) samples

Four DQOs have been identified for the 0-45-cm sediment samples to be collected in potential clamming and beach play areas to establish baseline concentrations and provide a foundation for assessing trends. These DQOs are summarized in Table 2-2.

Table 2-2. DQOs for intertidal surface sediment samples (0–45 cm)

Step	DQO 76	DQO 87	DQO 98	DQO 109
STEP 1: State the problem.	A synoptic site-wide sediment dataset is needed to assess the baseline condition in potential clamming areas prior to implementation of the sediment remedy.		Sediment concentration data from beach play areas are needed prior to implementation of the sediment remedy.	
STEP 2: Identify the goals of the study.	Establish a baseline, site-wide 95UCL concentration of RAO 2 risk drivers across all potential clamming areas within the LDW.	Establish a baseline, site-wide mean concentration in potential clamming areas to serve as the foundation for assessing temporal trends for RAO 2 risk drivers.	Establish baseline 95UCL concentrations of human health risk drivers for RAO 2 within each of the 8 beach play areas of the LDW.	Establish baseline mean concentrations to serve as a foundation for assessing temporal trends in the 8 beach play areas for RAO 2 risk drivers.
STEP 3: Identify the information inputs.	Spatial area estimates for the potential clamming areas identified in the ROD were used to determine the appropriate number of sampling locations across the entire potential clamming area to achieve approximately spatially proportional sampling.		Spatial area estimates for the beach play areas identified in the ROD were used to determine the appropriate number of locations within each beach play area to achieve approximately proportional sampling by beach.	
STEP 4: Define the boundaries of the study.	The boundaries of the potential clamming areas were defined in the ROD.		The boundaries for each of the 8 beach play areas were defined in the ROD.	
STEP 5: Develop the analytical approach.	The baseline 95UCL will be calculated using a <i>t</i> -interval, and will be justified by invoking the CLT due the large number of field samples (n = 71) per analytical sample.	The baseline mean will be estimated as the arithmetic mean of the 3 potential clamming area-wide composites.	The baseline 95UCL will be calculated using a <i>t</i>-interval if it is possible to illustrate approximate normality with previously collected RI/FS data; if it is not, the 95UCL will use the Chebyshev Inequality.	The baseline mean for each beach play area will be estimated as the arithmetic mean of the 3 composites from each beach.
STEP 6: Specify performance or acceptance criteria.	Performance or acceptance criteria are described in Section 4.6, including field QC samples and laboratory QC samples. DQIs for laboratory analyses (i.e., PARCCS) will be met, as described in Section 4.6.			
STEP 7: Develop the detailed plan for obtaining data.	Three site-wide composite samples will be prepared from samples collected from 71 spatially balanced random locations throughout the potential clamming areas in the LDW. At each of the 71 locations, 3 separate samples will be collected (in close proximity to each other) for a total of 213 samples. One of the 3 samples from each location will be included in 1 of the 3 site-wide composite samples, each composite representing the LDW-wide potential clamming area.		Three composite samples will be assembled for each of the 8 beach play areas for a total of 24 composite beach play area samples. Spatially balanced random samples will be collected from a total of 43 locations within beach play areas site wide. The number of sampling locations per beach will be approximately proportional to the size of the beach play area, and will range from 3 to 9. At each sampling location, 3 separate samples will be collected (in close proximity to each other) for a total of 129 samples. One of the 3 samples from each location will be included in 1 of the 3 beach-specific composite samples.	

95UCL – 95% upper confidence limit for the mean

CLT – Central Limit Theorem

DQI – data quality indicator

DQO – data quality objective

LDW – Lower Duwamish Waterway

PARCC – precision, accuracy, representativeness, completeness, comparability, and sensitivity

QC – quality control

RAO – remedial action objective

ROD – Record of Decision

~~RI/FS – remedial investigation/feasibility study~~

2.1.32.1 Intertidal baseline sediment for direct contact RAO 2 – potential clamming areas

The DQOs for the collection and analysis of surface sediment samples (0–45 cm) for RAO 2 in potential clamming areas are as follows:

7. Establish baseline 95UCL concentrations of human health risk drivers for RAO 2 across all potential clamming areas identified in the ROD.
8. Establish baseline site-wide potential clamming area mean concentrations to assess trends following sediment remediation for RAO 2 (direct contact – clamming) risk drivers.

Potential clamming areas will be sampled to assess baseline conditions in these intertidal areas throughout the LDW. Three site-wide composite samples will be prepared from samples collected from 71 spatially balanced¹⁸ locations throughout the potential clamming areas in the LDW. At each of the 71 locations, 3 separate samples will be collected (in close proximity to each other) for a total of 213 samples in the potential clamming areas.

Concentrations in each composite sample represent the site-wide mean concentration; the three composites are independent estimates of the mean. The variance among the composite sample concentrations will be used to calculate the site-wide potential clamming area 95UCL.

The composite samples will be analyzed for human health direct contact COCs (PCBs, total arsenic, cPAHs, and dioxins/furans) identified in ROD Table 19. The samples will also be analyzed for toxaphene, which is identified in ROD Table 14 as a direct contact contaminant of potential concern (COPC) (EPA 2014b).¹⁹

2.1.32.2 Intertidal baseline sediment for direct contact RAO 2 – beach play areas

The DQOs for the collection and analysis of surface sediment samples (0–45 cm) for RAO 2 in beach play areas are as follows:

9. Establish baseline 95UCL concentrations for risk drivers to achieve RAO 2 in each of the eight beach play areas.
10. Establish baseline beach play area-specific mean concentrations to assess trends following sediment remediation for RAO 2 (direct contact – beach play) risk drivers.

¹⁸ The total number of locations within each potential clamming area is roughly proportional to the size of the area.

¹⁹ ROD Table 14 is titled *Summary of COPCs and Rationale for Selection as COCs for Human Health Exposure Scenarios*.

Baseline conditions within each of the eight beach play areas will be characterized with three composite samples from each beach play area. The number of locations within each beach play area composite sample will be roughly proportional to the size of each beach play area, varying from 3 to 9 locations per beach play area, for a total of 43 locations site-wide. Concentrations in each composite sample will represent the mean concentration at each beach; thus, the three composites will be independent estimates of the beach-wide mean, capturing small-scale spatial variability as well as sampling and analytical error. The variance among the composite sample concentrations will be used to calculate the 95UCL by beach.

These composite samples will be analyzed for human health direct contact COCs (PCBs, total arsenic, cPAHs, and dioxins/furans) identified in ROD Table 19 (EPA 2014b). The samples will also be analyzed for toxaphene, which is identified in ROD Table 14 as a direct contact COPC.

2.2 PROJECT APPROACH AND SCHEDULE

Two separate sampling events will be conducted to address the ~~nine-10~~ surface sediment DQOs described in Section 2.1. Figure 2-3 presents the schedule for the surface sediment sampling events and the porewater investigation.

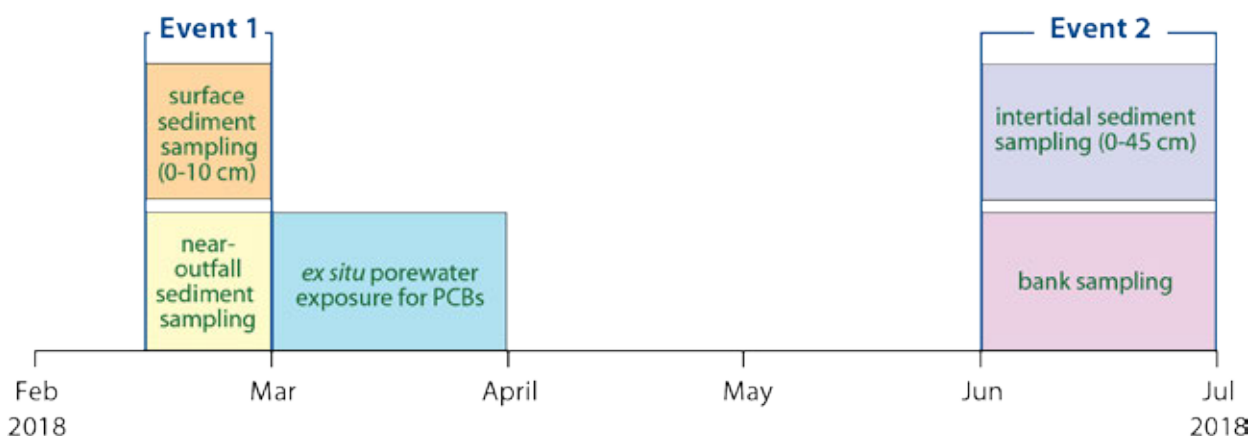


Figure 2-3. Timeline showing target schedule for the two surface sediment sampling events and the *ex situ* porewater laboratory exposure period

Sampling of the 0–10-cm sediment samples (including near-outfall sampling) is scheduled to begin in mid-February 2018;²⁰ the chemical analysis and ~~one-month~~28-day *ex situ* porewater laboratory exposure will begin when the 0–10-cm sediment sampling and compositing is complete. The 0–45-cm and bank soil sampling will be conducted in June 2018 during the period of daytime low tides.²¹ Chemical analysis of

²⁰ The exact field schedule will be finalized after this QAPP is approved.

²¹ Near-outfall sediment sampling locations that are not accessible by boat may be sampled from shore at low tide during Sampling Event 2.

the samples will begin when the sampling and the compositing of the 0–45-cm samples is complete. Field conditions or logistics may require deviations from these target timeframes; such deviations will be communicated to EPA as they are realized and noted in the data reports (described below).

Chemical analysis of the samples from each sampling event will require approximately four weeks.²² Data validation will be completed approximately three weeks after receipt of the chemistry data. EPA will be notified when the final data validation report has been received for each event.

Draft sampling data reports for each event (Work Plan Task 5 (Windward and Integral 2017b)) will be submitted to EPA 21 days after receipt of the final validated analytical results. The first data report will contain the results of Sampling Event 1 in February. The second of the two data reports will contain the results of Sampling Event 2 in June and the *ex situ* porewater investigation results. Draft final data reports will be submitted to EPA 30 days after receipt of EPA’s comments on the draft data reports. Final validated data will be submitted to Ecology’s Environmental Information Management (EIM) system and EPA’s Scribe database within 30 days of the approval of the final data report. Surface sediment and porewater data will be evaluated in the data evaluation report (Work Plan Task 6).

²²~~The identification of near-outfall and bank samples for dioxin/furan analysis will be conducted based on the dioxin/furan results for nearby surface sediment samples. Therefore, this analysis of dioxins/furans in near-outfall and bank samples will be completed approximately 10 weeks after the samples have been collected.~~

3 Project Organization and Responsibilities

The overall project organization and the individuals responsible for the various tasks required for surface sediment sample collection and analysis are shown in Figure 3-1. Responsibilities of project team members, as well as laboratory project managers (PMs), are described in the following sections.

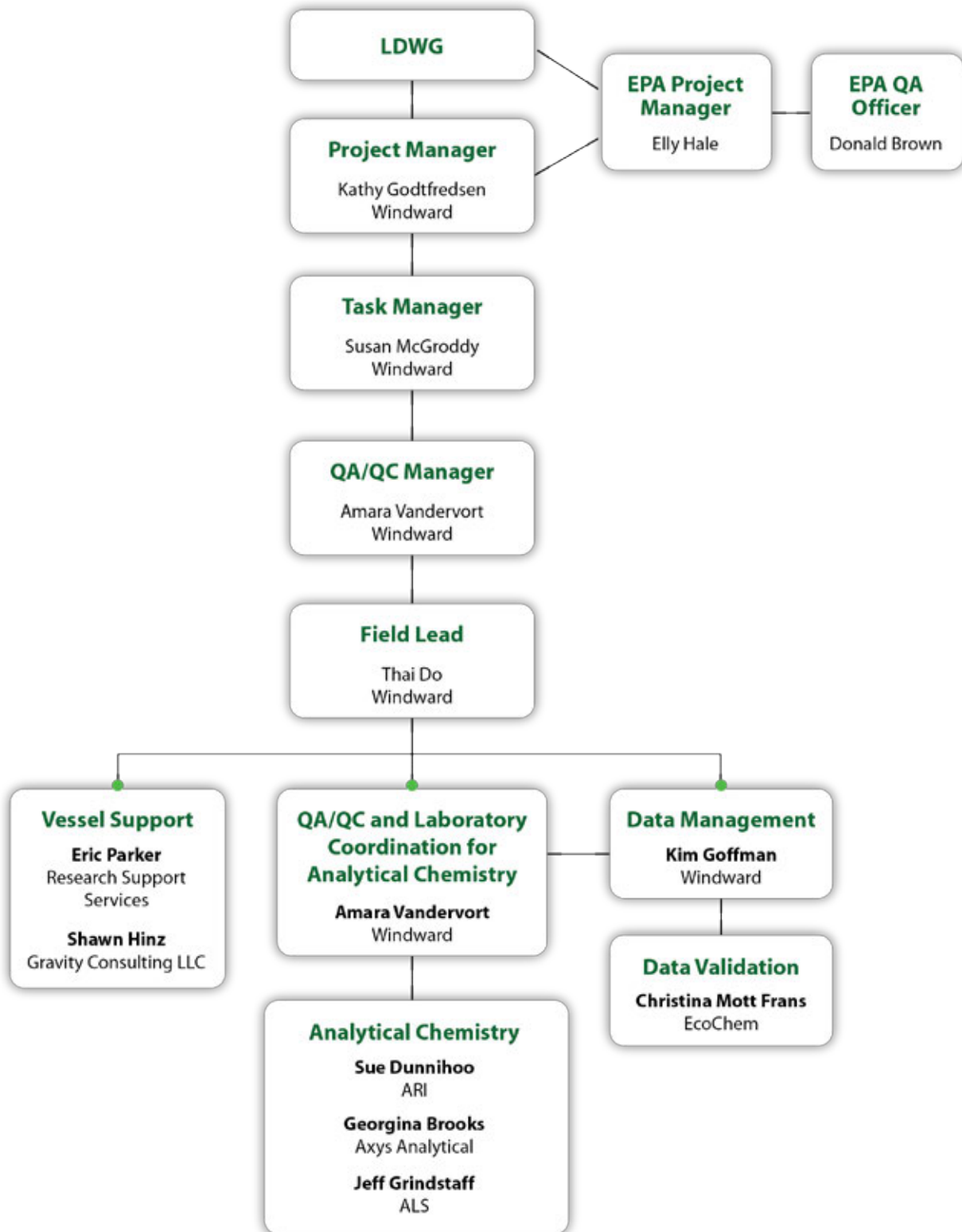


Figure 3-1. Project organization and team responsibilities

3.1 PROJECT MANAGEMENT

Both the Lower Duwamish Waterway Group (LDWG) and EPA are involved in all aspects of this project, including discussion, review, and approval of this QAPP, and interpretation of the results of the investigation. Elly Hale is the EPA PM for the pre-design studies (EPA 2016c).

Kathy Godtfredsen is the Windward Environmental LLC (Windward) PM. In this capacity, she will be responsible for overall project coordination, and for providing oversight for planning and coordination, work plans, all project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. She will also be responsible for coordinating with LDWG and EPA on schedule, deliverables, and other administrative details. Dr. Godtfredsen can be reached as follows:

Dr. Kathy Godtfredsen
Windward Environmental LLC
200 West Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.577.1283
E-mail: kathyg@windwardenv.com

Susan McGroddy is the Windward monitoring task manager (TM). As TM, she will be responsible for communicating with the Windward PM on the progress of project tasks, conducting detailed planning and coordination, and monitoring and communicating any deviations from the QAPP. Significant deviations from the QAPP will be further reported to representatives of LDWG and EPA. Dr. McGroddy can be reached as follows:

Dr. Susan McGroddy
Windward Environmental LLC
200 West Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5421
E-mail: susanm@windwardenv.com

3.2 FIELD COORDINATION

Thai Do is the Windward field coordinator (FC). As FC, he will be responsible for managing field sampling activities and general field and QA/quality control (QC) oversight. He will ensure that appropriate protocols are observed for sample collection, preservation, and holding times, and will oversee delivery of environmental samples to the designated laboratories for chemical analyses. The FC will report deviations from this QAPP to the TM and PM for consultation. Significant deviations from the QAPP will be further reported to representatives of LDWG and EPA. Mr. Do can be reached as follows:

Mr. Thai Do
Windward Environmental LLC
200 West Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5407²³
Email: thaid@windwardenv.com

Eric Parker is ~~the one of two~~ boat captains. He will be responsible for operating the boat, and will coordinate closely with the FC to ensure that samples are collected in keeping with the methods and procedures presented in this QAPP. Mr. Parker can be reached as follows:

Mr. Eric Parker
Research Support Services
321 High School Road NE D3/563
Bainbridge Island, WA 98110
Mobile: (b) (6)
Email: eparker@rssincorporated.com

Shawn Hinz is the other boat captain. He will be responsible for operating the boat and will coordinate closely with the FC to ensure that samples are collected in keeping with the methods and procedures presented in this QAPP. Mr. Hinz can be reached as follows:

Mr. Shawn Hinz
Gravity Consulting LLC
32617 Southeast 44th Street
Fall City, WA 98024
Mobile: (b) (6)
Email: shawn@gravity.com

3.3 QUALITY ASSURANCE/QUALITY CONTROL

Amara Vandervort is the Windward QA/QC coordinator. In this capacity, she will oversee coordination of the field sampling and laboratory programs, and will supervise data validation and project QA coordination, including coordination with the analytical laboratories and the EPA QA officer, Donald Brown. Ms. Vandervort will also maintain

²³ This is Mr. Do's office phone number. A mobile phone number will be provided prior to field sampling.

the official approved QAPP and ensure that the appropriate parties receive any updated versions of the QAPP. Ms. Vandervort can be reached as follows:

Ms. Amara Vandervort
Windward Environmental LLC
200 West Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5415
Email: amarav@windwardenv.com

Mr. Brown can be reached as follows:

Mr. Donald Brown
US Environmental Protection Agency, Region 10
1200 6th Avenue
Seattle, WA 98101
Telephone: 206.553.0717
Email: brown.donaldm@epa.gov

Independent third-party chemical data review and validation will be provided by EcoChem. The PM at EcoChem can be reached as follows:

Ms. Christina Mott Frans
EcoChem
1011 Western Avenue, Suite 1006
Seattle, WA 98104
Telephone: 206.508.2110
Email: cmfrans@ecochem.net

3.4 LABORATORY RESPONSIBILITIES

Amara Vandervort of Windward is the laboratory coordinator for the analytical chemistry laboratories. Analytical Resources, Inc. (ARI) will perform all chemical analyses on the surface sediment samples, with the exception of analyses for dioxins/furans, PCB congeners, and black carbon. Axys Analytical Services Ltd. (Axys) will prepare the porewater passive samplers and perform analyses for PCB congeners and dioxins/furans. ALS Environmental-Kelso (ALS) will perform analyses for black carbon.

The laboratory PM at ARI can be reached as follows:

Ms. Susan Dunnihoo
Analytical Resources, Inc.
4611 South 134th Place
Tukwila, WA 98168-3240
Telephone: 206.695.6207
Email: limsadm@arilabs.com

The laboratory PM at Axys can be reached as follows:

Ms. Georgina Brooks
Axys Analytical Services Ltd.
2045 West Mills Road
Sidney, British Columbia V8L 5X2
Canada
Telephone: 250.655.5801
Email: Georgina.Brooks@sgs.com

The laboratory PM at ALS can be reached as follows:

Mr. Jeff Grindstaff
ALS Environmental-Kelso
1317 13th Avenue South
Kelso, WA 98626
Telephone: 360.577.7222
Email: Jeff.Grindstaff@alsglobal.com

ARI, ALS, and Axys will meet the following requirements:

- u Adhere to the methods outlined in this QAPP, including those methods referenced for each procedure.
- u Adhere to documentation, custody, and sample logbook procedures.
- u Implement QA/QC procedures defined in this QAPP.
- u Meet all reporting requirements.
- u Deliver electronic data files as specified in this QAPP.
- u Meet turnaround times for deliverables as described in this QAPP.
- u Allow EPA and the QA/QC manager, or a representative, to perform laboratory and data audits.

3.5 DATA MANAGEMENT

Kim Goffman of Windward will oversee data management, and will ensure that analytical data are incorporated into the LDW database with appropriate qualifiers

following acceptance of the data validation. QA/QC of the database entries will ensure accuracy for use in the pre-design studies. Ms. Goffman can be reached as follows:

Ms. Kim Goffman
Windward Environmental LLC
200 West Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5414
Email: king@windwardenv.com

3.6 SPECIAL TRAINING/CERTIFICATION

The Superfund Amendments and Reauthorization Act of 1986 required the Secretary of Labor to issue regulations through the Occupational Safety and Health Administration (OSHA) providing health and safety standards and guidelines for workers engaged in hazardous waste operations. Accordingly, 29 Code of Federal Regulations (CFR) 1910.120 requires that employees be given the training necessary to provide them with the knowledge and skills to enable them to perform their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hour HAZWOPER training and 8-hour refresher courses, as necessary, to meet OSHA regulations.

Also, ARI and Axys have current environmental laboratory accreditation from Ecology for methods to be performed. Ecology does not offer accreditation for the black carbon method. However, ALS is International Organization for Standardization (ISO) accredited for the instrumental portion of black carbon analysis, which is the only accreditation available for this method.

3.7 DOCUMENTATION AND RECORDS

All field activities and laboratory analyses will be documented following the protocols described in this section. In addition, data reduction rules and data report formats are provided herein.

3.7.1 Field observations

All field activities will be recorded in a field logbook maintained by the FC or designee. The field logbook will provide a description of all sampling activities, conferences between the FC and EPA oversight personnel associated with field sampling activities, sampling personnel, and weather conditions, as well as a record of all modifications to the procedures and plans identified in this QAPP and the HSP (Appendix A). The field logbook will consist of bound, numbered pages, and all entries will be made in indelible ink. Photographs, taken with a digital camera, will provide additional documentation of the surface sediment collection activities and all bank sampling areas. The field logbook is intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the sampling period.

The following field data collection sheets, included as Appendix B, will also be used to record pertinent information after sample collection:

- u Surface sediment collection form
- u Bank collection form
- u Percent moisture benchsheet for *ex situ* porewater investigation
- u Exposure setup benchsheet for *ex situ* porewater investigation
- u Daily conditions benchsheet for *ex situ* porewater investigation
- u Protocol modification form

Information regarding equipment calibration and other sampling activities will be documented in the field logbook.

3.7.2 Laboratory records

ARI, ALS, and Axys will be responsible for internal checks on sample handling and analytical data reporting, and will correct errors identified during the QA review. The laboratory data packages will be submitted electronically and will include the following, as applicable:

- u **Project narrative:** This summary, in the form of a cover letter, will present any problems encountered during any aspect of sample analyses. The summary will include, but not be limited to, discussion of QC, sample shipment, sample storage, and analytical difficulties. Any problems encountered by the laboratory will be documented, as will their resolutions. In addition, operating conditions for instruments used for the analysis of each suite of analytes and definitions of laboratory qualifiers will be provided.
- u **Records:** Legible copies of the chain of custody forms will be provided as part of the data package. This documentation will include the time of receipt and the condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented.
- u **Sample results:** The data package will summarize the results for each sample analyzed. The summary will include the following information, as applicable:
 - u Field sample identification (ID) code and the corresponding laboratory ID code
 - u Sample matrix
 - u Date of sample extraction/digestion
 - u Date and time of analysis
 - u Weight used for analysis

- u Final dilution volumes or concentration factor for the sample
- u Percent solids in the samples
- u Identification of the instruments used for analysis
- u Method detection limits (MDLs)²⁴ and RLs²⁵
- u All data qualifiers and their definitions
- u **QA/QC summaries:** These summaries will contain the results of all QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (see above). The laboratory will make no recovery or blank corrections, except for isotope dilution method correction prescribed in EPA methods 1613b and 1668c. The required summaries will include the following information, as applicable:
 - u The calibration data summary will contain the concentrations of the initial calibration and daily calibration standards and the date and time of analysis. The response factor, percent relative standard deviation (%RSD), relative percent difference (RPD), and retention time for each analyte will be listed, as appropriate. Results for standards analyzed to indicate instrument sensitivity will be reported.
 - u The internal standard area summary will report the internal standard areas, as appropriate.
 - u The method blank analysis summary will report the method blank analysis associated with each sample and the concentrations of all compounds of interest identified in these blanks.
 - u The surrogate spike recovery summary will report all surrogate spike recovery data for organic analyses. The names and concentrations of all compounds added, percent recoveries, and QC limits will be listed.
 - u The labeled compound recovery summary will report all labeled compound recovery data for EPA [methods](#) 1613b and 1668c [analyses](#). The names and concentrations of all compounds added, percent recovery, and QC limits will be listed.
 - u The matrix spike (MS) recovery summary will report the MS or MS/matrix spike duplicate (MSD) recovery data for analyses, as appropriate. The names and concentrations of all compounds added, percent recoveries, and QC limits will be included. The RPD for all MS and MSD analyses will be reported.

²⁴ The term MDL includes other types of detection limits (DLs), such as estimated detection limit (EDL) values calculated for PCB congeners and dioxin/furan congeners.

²⁵ RL values are consistent with the lower limit of quantitation (LLOQ) values required under EPA-846.

- u The matrix duplicate summary will report the RPD for all matrix duplicate analyses. The QC limits for each compound or analyte will be listed.
- u The standard reference material (SRM) analysis²⁶ summary will report the results of the SRM analyses and compare these results with published concentration ranges for the SRMs.
- u The LCS analysis summary will report the results of the analyses of LCSs. The QC limits for each compound or analyte will be included.
- u The relative retention time summary will report the relative retention times for the primary and confirmational columns of each analyte detected in the samples and the percent difference between the columns, as appropriate.
- u The ion abundance ratio summary for samples analyzed by EPA methods 1613b and 1668c will report computed ion abundance ratios compared to theoretical ratios listed in the applicable method.
- u **Original data:** Legible copies of the original data generated by the laboratory will be provided, including the following:
 - u Sample extraction/digestion, preparation, and cleanup logs
 - u Instrument specifications and analysis logs for all instruments used on days of calibration and analysis
 - u Reconstructed ion chromatograms for all samples, standards, blanks, calibrations, spikes, replicates, LCSs, and SRMs
 - u Enhanced and unenhanced spectra of target compounds detected in field samples and method blanks, with associated best-match spectra and background-subtracted spectra, for all gas chromatography/mass spectrometry (GC/MS) analyses
 - u Enhanced and unenhanced spectra of target performance reference compounds (PRCs) detected in field samples, day-zero blank, field blank, and method blanks, with associated best-match spectra and background-subtracted spectra, for all GC/MS analyses
 - u Quantitation reports for each instrument used, including reports for all samples, blanks, calibrations, MSs/MSDs, laboratory replicates, LCSs, and SRMs

ARI, ALS, and Axys will submit data electronically, in EarthSoft EQUIS® standard four-file or EZ_EDD format. Guidelines for electronic data deliverables for chemical

²⁶ SRMs will be analyzed for polycyclic aromatic hydrocarbons (PAHs), PCB Aroclors, dioxins/furans, and PCB congeners. All other analyses will include a laboratory control sample (LCS). Specific information is listed in Section 4.7.

data are provided on the EarthSoft website, <http://www.earthsoft.com/en/index.html>, and additional information will be communicated to ARI, ALS, and Axy's by the project QA/QC coordinator or data manager. All electronic data submittals must be tab-delimited text files with all results, MDLs (as applicable), and RLs reported to the appropriate number of significant figures. If laboratory replicate analyses are conducted on a single submitted field sample, the laboratory sample identifier must distinguish among the replicate analyses.

3.7.3 Data reduction

Data reduction is the process by which original data (analytical measurements) are converted or reduced to a specified format or unit to facilitate analysis of the data. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce the data, which are subjected to further review and reduction by the laboratory PM, the Windward TM, the QA/QC coordinator, and independent reviewers. The data will be generated in a format amenable to review and evaluation. Data reduction may be performed manually or electronically. If performed electronically, all software used must be demonstrated to be true and free from unacceptable error.

3.7.4 Data report

Two data reports will be prepared documenting all activities associated with the collection, handling, and analysis of samples, as specified in Task 5 of the third amendment to the AOC (EPA 2016c). The first data report will document Sampling Event 1 and present the analytical results for the 0–10-cm sediment samples. The second data report will document the Sampling Event 2 and present the analytical results for any near-outfall samples that were collected during low tide, bank samples, and 0–45-cm sediment samples, as well as the analytical results of the *ex situ* porewater investigation.

The following information will be included in each data report:

- u Summary of all field activities, including descriptions of any deviations from the approved QAPP
- u Sampling locations reported in latitude and longitude to the nearest one-tenth of a second and in northing and easting to the nearest foot
- u Summary of the chemical data QA/QC review
- u Results from the analyses of field samples and *ex situ* analyses, included as summary tables in the main body of the report, data forms submitted by ARI, ALS, and Axy's, and cross-tab tables produced from Windward's database
- u Copies of field logs and photographs (appendix)

- u Copies of chain of custody forms (appendix)
- u Data validation report (appendix)

Once each data report has been approved by EPA, a database export will be created from Windward's database. The data will be exported in two formats: one that is compatible with Ecology's EIM system, and one that is compatible with EPA's Scribe database.

3.7.5 Data storage and backup

All electronic files related to the project will be stored on a secure server on Windward's network. The server contents are backed up on an hourly basis, and a copy of the backup is uploaded nightly to a secure off-site facility.

4 Data Generation and Acquisition

Surface sediment samples will be collected, processed, and analyzed according to the procedures described in this section. In addition, methods for the *ex situ* porewater investigation are described herein. QA/QC, instrument maintenance and calibration, non-direct measurement, and data management requirements are also provided.

4.1 SAMPLING DESIGN

Sampling design components for sediment collections are detailed in the following sections. The study designs for the collection of the 0–10-cm surface sediment grab samples, related composites, and sediment samples for the *ex situ* porewater investigation are described in Section 4.1.1. The analyses to determine the locations for targeted source-related sampling of sediments near outfalls and banks are presented in Section 4.1.23. The study designs for the intertidal 0–45-cm surface sediment composite samples from potential clamming areas and the eight beach play areas are detailed in Section 4.1.32. ~~The analyses to determine the locations for targeted source-related sampling of sediments near outfalls and banks are presented in Section 4.1.3.~~

4.1.1 Surface sediment samples (0–10 cm)

This section presents the sampling design for the 0–10-cm surface sediment samples that will be collected to evaluate DQOs 1 through 5 (Table 2-1). The sampling design used to characterize surface sediment concentrations was statistically based to ensure representative-unbiased coverage of the LDW to generate the data needed for the DQOs.

Random sampling was used to satisfy DQOs 1 and 2. A subset of these samples was As part of this design, random sampling was augmented with non-random sampling (i.e., reoccupation of RI locations) to provide ~~useful~~ data for ~~each~~ DQOs 3 through 5. An overview of the design is presented in Table 4-1, and details about the sample sizes and how the sampling locations were selected for each DQO are presented below.

Table 4-1. Overview of 0–10-cm surface sediment sampling approach

Design Component	Approach			
	DQOs 1 and 2 – Site-wide 95UCL and Mean SWAC	DQO 3 – Point-by-Point Evaluation	DQO 4 – Trend Support	DQO 5 – Ex Situ Porewater Evaluation
Sediment sample type	composites of grab samples	individual grab samples	individual grab samples	individual grab samples
Sample size	24 composite samples (7 grab samples each)	20 grab samples	10 grab samples	1620 grab samples

Design Component	Approach			
	DQOs 1 and 2 – Site-wide 95UCL and <u>MeanSWAC</u>	DQO 3 – Point-by-Point Evaluation	DQO 4 – Trend Support	DQO 5 – Ex Situ Porewater Evaluation
Sampling locations	168 <u>random</u> locations (16 non-random and 152 random) spatially balanced across the LDW	20 locations (10 non-random <u>reoccupied RI locations</u> and 10 random) within MNR areas.	10 non-random <u>reoccupied RI</u> locations within MNR areas	1620 candidate locations with targeted PCB concentrations <u>based on RI/FS data</u>

95UCL – 95% upper confidence limit for the mean

DQO – data quality objective

LDW – Lower Duwamish Waterway

MNR – monitored natural recovery

PCB – polychlorinated biphenyl

RI/FS - remedial investigation/feasibility study

SWAC - spatially weighted average concentration

The sampling design for collecting the baseline surface sediment samples that will be used to estimate the site-wide 95UCL and the SWAC (DQOs 1 and 2) is based on a spatially balanced random sampling design with composite samples.

Locations

A spatially balanced random sampling design was used because it provided an efficient way to ensure that the dataset had an equal chance of capturing all areas within the waterway while avoiding randomly clustered sampling locations that could overly influence mean and variance. Spatial balance was achieved using a stratified design, which placed one sample per grid cell in each approximately equally sized grid cell.

~~This design resulted in a large random sample size that was augmented by a smaller set of non-random samples to support DQOs 3 through 5. The non-random locations represented less than 10% of the total number of samples collected for the baseline site-wide estimates. Sediment from these non-random samples will be combined with sediment from random samples to generate the composites used for the site-wide estimates of mean and variance.~~

Sample Size

The total number of grid cells selected to characterize the site-wide average (as SWAC and 95UCL) was based on simulated variance estimates and EPA direction (Section 2 of Appendix A to the Work Plan (Windward and Integral 2017b)). The sampling design included 24 composite samples of 7 samples each (for a total of 168 field samples), and used an irregular grid of 168 cells of approximately equal area. This

approach is expected to result in a relative margin of error (RME)²⁷ for the mean of 25% or less,²⁸ which is less than analytical variability.²⁹

~~Of the 168 locations, 16 are non-random. Ten of the 16 were selected to reoccupy locations of previous SCO exceedances in order to address DQOs 3 and 4, and the remaining 6 were selected to increase the PCB concentration range for the ex-situ porewater investigation (DQO 5).~~

Once collected, the surface sediment samples from these 168 cells ~~(16 non-random and 152 random)~~ will be combined into 24 composite samples for analysis (Map 4-1), and individual samples will be archived. Each composite sample will contain seven samples from neighboring grid cells (Map 4-1). The composite areas and the remedy technology assignments (as preliminarily mapped in the ROD Figure 18 (EPA 2014b)) are provided in Map 4-2.

In future years of monitoring, the number of samples per composite should remain consistent to maintain year-to-year comparability of the datasets. ~~However, t~~The numbers of field samples and composite samples may change in response to updated information about site variance, and to achieve a desired RME for the site-wide mean. In this way, a robust site-wide SWAC and 95UCL can be calculated for each sampling event.

A total of 188 0–10-cm surface sediment samples will be collected. The 168 random locations (sample locations 1 through 168 on Map 4-3) will contribute to the site-wide composites to address DQOs 1 and 2. Ten of the random locations that are located in MNR areas will also be analyzed for SMS analytes as individual samples to address DQOs 3 and 4 (Table 4-2). In addition, 10 reoccupied RI locations will also be analyzed for SMS analytes to address DQOs 3 and 4.

~~address DQOs 3, 4, or 5~~To address DQO 5, splits from the 10 reoccupied RI locations and samples from 10 additional locations will be analyzed for PCBs as summarized in (Table 4-2).

²⁷ RME is measured as the width of the 95UCL as a percent of the mean.

²⁸ The expectation of 25% RME or better for the mean was based on a normal distribution and a coefficient of variation of 0.7, or less, for the composite sample dataset.

²⁹ The analytical precision required by EPA functional guidelines for the analytical methods typically used in sediment characterization ranges from 20 to 50%, comparable to a range of 16 to 42% for RME as defined for this project.

Table 4-2. Location and rationale for 0–10-cm grab samples to be analyzed individually~~collected to address DQOs 3, 4, or 5 (in addition to DQOs 1 and 2)~~

Sample Location	RM	Reoccupied RI Location	PCB Conc. (µg/kg)	DQO 3	DQO 4	DQO 5
Random locations within MNR areas <u>(sample splits)</u>						
8	0.1	na	na	X	X	
23	0.5	na	na	X	X	
40	0.7	na	na	X	X	
52	0.9	na	na	X	X	
69	1.4	na	na	X	X	
91	2.1	na	na	X	X	
101	2.4	na	na	X	X	
130	3.5	na	na	X	X	
143	4.1	na	na	X	X	
161	4.7	na	na	X	X	
Reoccupied RI locations						
169	0.3	DR005	168	X	X	X
170	0.6	DR010	74	X	X	X
171	0.6	DUD040	620			X
172	0.6	LDW-SS312	1,010			X
173	0.7	DR083	567			X
174	0.7	WIT288	340	X	X	X
175	0.8	LDW-Pilot 4B-SS4	1,640			X
176	1.0	LDW-SS321	450			X
177	1.5	LDW-SS57	750			X
178	1.6	DR092	64	X	X	X
179	2.1	DR111	311 (1998), 176 (2004)	X	X	X
180	2.2	2154-DSS-21	1,520			X
181	2.2	DR139	2,830			X
182	2.2	B5a-2	1,730			X
183	2.5	WRC-SS-B3	18	X	X	X
184	3.0	WIT270	100	X	X	X
185	3.7	SD-336-S	250			X
186	3.9	DR258	62	X	X	X
187	4.5	DR290	170	X	X	X
188	5.0	DR276	32	X	X	X

DQO – data quality objective
PCB – polychlorinated biphenyl
MNR – monitored natural recovery
na – not applicable or available

RI – remedial investigation/~~feasibility study~~
RM – river mile
SCO – sediment cleanup objective

4.1.23 Targeted source-related sampling

In addition to the baseline sediment samples discussed in Sections 4.1.1 and 4.1.32, targeted source-related sediment sampling will be conducted ~~under the third amendment to the AOC. These samples are intended to address DQO 6~~ to “help Ecology assess the sufficiency of contaminant source control through additional near-outfall sediment sampling and bank sampling” (EPA 2016c).

4.1.23.1 Near-outfall sediment sampling

Near-outfall sediment samples (0-10-cm) will be collected as part of targeted source-related sampling. In 2014, Leidos conducted an assessment to identify sediment data gaps near outfalls, evaluate the feasibility of filling those gaps, and provide information needed to conduct additional outfall sediment sampling (Leidos 2014a). The list that Leidos developed was then screened against additional criteria presented in the Work Plan and in Figure 4-1 herein (Windward and Integral 2017b).

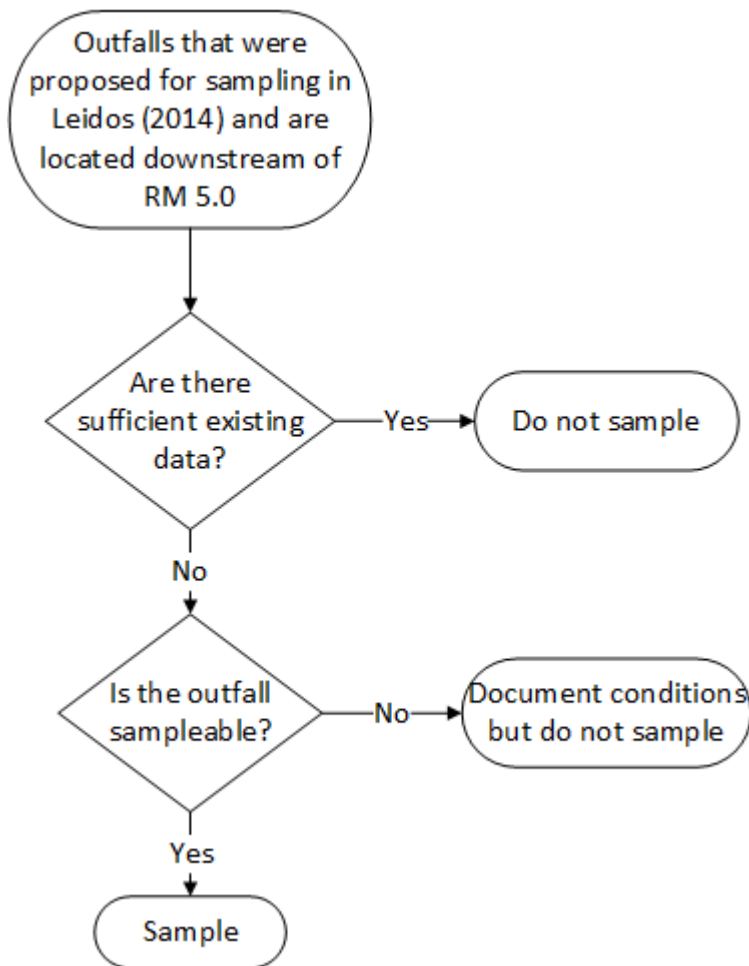


Figure 4-1. Selection criteria for sampling sediment near active outfalls

Leidos (2014a) recommended 68 outfalls for additional sediment sampling. Eight of these outfalls are located outside of the site boundaries or have not been located: five (Outfalls E&E-2, E&E-3, E&E-4, 3842, and 3921) are located south of river mile (RM) 5.0, two (Outfalls 8132 and 8133) are located north of RM 0.0, and the location of Outfall 2167 is unknown. All of these outfalls were therefore excluded. The remaining 60 outfalls are circled on Map 4-~~46~~.

To determine whether sufficient surface sediment data exist in the vicinity of these 60 outfalls, all available surface sediment data³⁰ within approximately 50 ft of outfalls with diameters of 24 in. or less, and within approximately 100 ft of outfalls with diameters greater than 24 in., were considered (Map 4-~~46~~). Of the 60 outfalls, 26 had sufficient surface sediment sample locations within approximately 50 or 100 ft (Table 4-~~36~~). These 26 outfalls will not be sampled.

³⁰ All data from the RI/FS dataset were considered, as well as those compiled as part of Task 2 of the Work Plan (Windward and Integral 2017b).

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
2156	0	18	screen out (not sampleable due to riprap/rocky substrate)	0	did not sample during Phase I because of riprap/rocky substrate			0
2151	0	12	screen out (not sampleable due to riprap/rocky substrate)	0	did not sample during Phase I because of riprap/rocky substrate			0
HRE-1	0	18	screen out (not sampleable due to riprap/rocky substrate)	0	did not sample during Phase I because of riprap/rocky substrate			0
2154	0	6	screen out (not sampleable due to riprap/rocky substrate)	0	did not sample during Phase I because of riprap/rocky substrate			0
S Nevada St SD	0.3 E	18	screen out (not sampleable due to riprap/rocky substrate)	0	did not sample during Phase I because of riprap/rocky substrate		"never been found," per Ecology	0
2225	0.6 E	18	screen out (sufficient data)	1		1 sample within 50-ft buffer zone and 4 additional samples within 135 ft		0
2003	0.7 E	12	try to sample during low tide	0	did not sample during Phase I because of riprap/rocky substrate (but noted that sampling may be possible by foot during low tide)	existing sediment sample within 61 ft; outfall is within potential Clamming Subarea 3; will collect a sample during Sampling Event 2		1
2006	0.7 E	12	screen out (not sampleable due to riprap/rocky substrate)	0	did not sample during Phase I because of riprap/rocky substrate		outfall plugged, per King County	0

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
FedCtrS	0.8 E	unknown	sample	0		two existing sediment samples within 100 ft; outfall in potential Clamming Subarea 3; will collect a sample during Sampling Event 2		1
2005	0.9 E	8	screen out (not sampleable due to riprap/rocky substrate)	0	did not sample during Phase I because of riprap/rocky substrate			0
2004	0.9 E	8	screen out (not sampleable due to dock)	0	did not sample during Phase I because of obstructions (dock)			0
2014	1.6 E	24	screen out (not sampleable due to riprap/rocky substrate)	0	did not sample during Phase I because of riprap/rocky substrate			0
GlacierNW-CBP	1.7 E	unknown	sample	0		located in Slip 2, numerous other samples in slip		1
GenBiodiese I	1.7 E	not reported	sample	0		located in Slip 2, numerous other samples in slip		1
2503 (1st Ave. S Bridge SD)	2.0 E	36	screen out (sufficient data)	0	collected 1 sample near mouth of 100-ft drainage ditch where outfall is located	not sampleable due to riprap and other armoring		0
SCS Refd Services	2.1 E	unknown	screen out (not sampleable due to overwater structures and armoring)	0		located in Slip 3; not sampleable due to structures and armoring (wooden piles and riprap) along the shoreline		0

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
Seattle Dist Ctr	2.1 E	10	sample	0		near Outfall 2025 at head of Slip 3, numerous other samples in vicinity at head of Slip 3		1
2025	2.1 E	unknown	screen out (sufficient data)	1		1 sample within 50 ft and 3 additional samples within 135 ft at the head of Slip 3; located near Seattle Dist Ctr; unclear if 2025 is an outfall or seep		0
Dawn Foods	2.3 E	unknown	sample	1		1 sample within 50-ft buffer	Per the City of Seattle, this outfall drains stormwater from 6 catch basins on the Dawn Foods property. Dawn Foods has identified a pipe that enters its collection system from off-site to the south (Seattle Boiler Works), but no additional information is available. A riprap bank exists.	1
Clean-Scapes B	2.7 E	unknown	sample	0		9 samples within 235 ft; two of these samples just outside 50 ft but are older; outfall is within potential Clamming Subarea 10; will collect a sample during Sampling Event 2		1
2052	2.9 E	30	screen out (sufficient data)	6				0
2088	4.4 E	36	screen out (sufficient data)	3				0

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
BDC-1	4.4 E	unknown	screen out (sufficient data)	1		1 sample within 50 ft and 2 additional samples within 75 ft; located within 34 ft of Outfall 2088		0
2087	4.4 E	36	screen out (sufficient data)	8				0
2085	4.5 E	36	screen out (sufficient data)	5				0
BDC-3	4.7 E	unknown	screen out (sufficient data)	1		1 sample within 50 ft and 11 samples within 165 ft		0
E&E-1	5.0 E	unknown	screen out (sufficient data)	1		1 sample within 50 ft and 5 samples within 110 ft		0
8134	0.0 W	na	sample	0		outfall reportedly located in a ditch; will attempt to collect 1 sample in the ditch if ditch can be located		1
2232	0.2 W	18	screen out (sufficient data)	0		3 samples within 80 ft		0
2157	0.4 W	24	screen out (not sampleable due to dock)	1	did not sample during Phase I because of obstructions (dock extending over and beyond outfall)	could not see outfall during recon because of the large over-water structure and barges		0
2226 (Herring's House Park)	0.5 W	na	sample if accessible	0	did not sample during Phase I because property access was unavailable	outfall is a creek; access may be difficult by land, and there is riprap in and near the creek; shoreline area north of creek covered by a wooden pier; access limited		1

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
Evergreen Trails	0.5 W	unknown	screen out (sufficient data)	2		2 samples within 50 ft and 2 additional samples within 100 ft		0
T107 Park	0.6 W	unknown	sample	0		area is shallow, contains riprap, and is in potential Clamming Subarea 2; will try to collect a sample during Sampling Event 2	Per the City of Seattle, SoundEarth (2011) refers to a pipe outlet that was observed near the ravine on the northern portion of the T-107 park property during a site reconnaissance; no flow was observed, and the location of the pipe inlet is unknown. In addition, a stormwater pipe with input from a catch basin located near the public parking lot transmits water to a grass swale. Area is largely undeveloped. There are no known historical sources.	1
5005	1.2 W	48	screen out (sufficient data)	2		2 within 100 ft and 3 within 125 ft; approximately co-located with Outfall 2137		0
2137	1.2 W	24	screen out (sufficient data)	0	did not sample during Phase I because location overlaps with Outfall 5005 (only planned for adjacent sample)	outfall is located adjacent to Outfall 5005		0

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
AML-DP2	1.3 W	unknown	screen out (sufficient data)	1		1 sample within 50 ft and an additional 4 samples located within 130 ft; almost co-located with Outfall AML-DP3		0
AML-DP3	1.3 W	unknown	screen out (sufficient data)	0		5 samples located within 135 ft; almost co-located with Outfall AML-DP2		0
2220	1.8 W	20	screen out (sufficient data, over-water structure, and riprap/rocky substrate)	1	did not sample during Phase I because of obstructions (bulkhead) and riprap/rocky substrate	1 sample within 50-ft buffer; outfall located at edge of over-water structure; likely riprap/rocky substrate in vicinity based on Leidos notes		0
2123	1.9 W	12	screen out (sufficient data)	1		1 sample within 50 ft and 4 additional samples within 115 ft; located within 45 ft of Outfall 2124		0
2124	1.9 W	18	screen out (sufficient data)	1		1 sample within 50 ft and 4 additional samples within 115 ft; located within 45 ft of Outfall 2123		0
2505	2.0 W	12	screen out (sufficient data)	1	did not sample during Phase I because of lack of DGPS while collecting on foot	1 sample within 50 ft and 5 additional samples within 135 ft		0
2507	2.1 W	8	sample	0		outfall is under the 1 st Ave. Bridge and is in potential Clamming Subarea 7; will collect a sample during Sampling Event 2	Per the City of Seattle, these outfalls are believed to be bridge drains. The outfalls, both of them small, are located in the channel downstream of a	1-2 as possible

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
2510	2.1 W	8	sample	0		outfall is under the 1 st Ave. Bridge and is in potential Clamming Subarea 7; will collect a sample during Sampling Event 2	large wetland by SR99. There is likely scour in this channel.	
2509	2.1 W	12	sample	0		outfall is under the 1 st Ave. Bridge and is in potential Clamming Subarea 7; will collect a sample during Sampling Event 2	Per the City of Seattle, this outfall is believed to be a bridge drain, but it appears to be at the same location as Outfall 2121. It is not clear whether this is a separate outfall. This location needs to be verified. There are 3 outfalls in this area.	1
2116	2.3 W	6	screen out (sufficient data at similar outfalls)	1	did not sample during Phase I because of riprap/rocky substrate (but noted that sampling may be possible by foot during low tide)	1 sample within 50-ft buffer; Outfall 2116 appears to drain the same property and operations as Outfalls Boyer-1, Boyer-2, and 2115, for which there are 10 additional samples within 115 ft		0
2114	2.4 W	6	sample if accessible	0	did not sample during Phase I because of obstructions (barges continuously docked in front of outfall)	could not see outfall during recon because of boats and barges in front of outfall		1 (if possible)

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
5th Ave S	2.5 W	unknown	sample	1		1 sample within 50-ft buffer zone but was only analyzed for grain size and PCBs; access could be an issue; outfall is located in potential Clamming Subarea 9; to collect a sample during Sampling Event 2	Per the City of Seattle, surface discharge is at the end of 5 th Avenue South. According to the United Iron Works SWPPP, surface runoff from this and several other facilities discharges to the LDW at this location. Neighbors occasionally cut an opening through the bank at this location to discharge stormwater that backs up on 5 th Avenue South/South Fontanelle Street. This is an area where the river overtops the bank during king tides.	1 (if possible)
2113 (S Webster St SD)	2.6 W	6	screen out (sufficient data and potential obstructions)	0	did not sample during Phase I because of obstructions (dock and catwalk on either side)	5 samples within 120 ft and uncertainty related to over-water structures		0
2110	2.9 W	15	screen out (sufficient data)	0	did not sample during Phase I because of obstructions (outfall located behind dock, crane, and catwalk)	1 sample located within 55 ft; adjacent to Outfall 2109		0

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
2109	2.9 W	11	sample if accessible	0	did not sample during Phase I because of obstructions (barges continuously docked in front of outfall)	appears sampleable now (no barges in front of outfall during recon); sample will be collected in vicinity of Outfall 2109 and Outfall 2110	Per the City of Seattle, outfall is near the end of South Chicago Street. Independent Metals currently operates on this parcel. There are multiple outfalls and sources along the shoreline opposite the former Independent Metals Plant 2 site. Stormwater from the on-site treatment system (Metals Rx) was discharged via Outfall L2106, but the entire shoreline was stacked with materials.	2
2215 (16 Ave S Bridge [west])	3.4 W	12	sample	0		numerous existing samples nearby; outfall is located in potential Clamming Subarea 13; will collect a sample during Sampling Event 2	Per King County, the County built a bioretention system to treat runoff from South Park Bridge.	1
South Park Marina	3.4 W	unknown	screen out (cleanup site)	0		South Park Marina is a cleanup site		0
2101	4.0 W	18	sample	0		numerous existing samples nearby		1
2100A (North Fork Hamm Creek)	4.2 W	72	sample	0				2
Delta Marine	4.2 W	unknown	sample	0		existing sample nearby		1

Table 4-36. Summary of screen to determine which areas to sample for sediment near outfalls

Outfall ^a	Location (approx. RM)	Outfall Diameter (in.)	Preliminary Assessment	No. of Sample Locations Within 50 or 100 ft ^b	Note from Leidos Documents on Sampleability	Notes from Windward: Sampleability Recon and Data Assessment	Additional Notes	Proposed No. of Samples
2205 (South Fork Hamm Creek)	4.3 W	na	screen out (sufficient data)	1		1 sample within 50 ft analyzed for TOC, grain size, and PCBs only; outfall is a creek; source tracing data indicate source control sufficiency (Leidos 2015; King County [in prep]).		0
DuwSD#3	4.4 W	8	sample	0		existing sample nearby; outfall in potential Clamming Subarea 15; will collect a sample during Sampling Event 2		1
2201	4.6 W	36	screen out (sufficient data)	1	did not sample during Phase I because property access was unavailable (property owned by Muckleshoot Tribe)	1 sample within 100-ft buffer zone and 3 additional samples within 130 ft		0
Ditch #1	4.7 W	na	screen out (sufficient data)	0		outfall is a ditch with 3 existing samples; existing data do not show exceedances except for 1 PCB exceedance that could not be replicated		0
Ditch #2	4.9 W	na	sample	0		outfall is a ditch, which will be sampled if possible		1 (in ditch)

Note: Leidos documents include Phase 1 data report (including field forms) and Phase 2 scoping document.

^a Source: Leidos (2014b)

^b This column lists the numbers of sample locations within 50 ft (outfall diameter ≤ 24 in.) or 100 ft (outfall diameter > 24 in.) from all RI/FS and Task 2 data.

City – City of Seattle

Ecology – Washington State Department of Ecology

DGPS – differential global positioning system

LDW – Lower Duwamish Waterway

LDWG – Lower Duwamish Waterway Group

PCB – polychlorinated biphenyl

RAL – remedial action level

RI/FS – remedial investigation/feasibility study

RM – river mile

SD – storm drain

SoundEarth – SoundEarth Strategies, Inc.

SWPPP – stormwater pollution prevention plan

T-107 – Terminal 107

Windward – Windward Environmental LLC

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Sampleability of sediment near the remaining 34 outfalls was assessed based on information provided by Leidos (2014a) and SAIC (2011) and a limited-scope field reconnaissance performed by boat on September 1 and September 25, 2017 (see Appendix E for field notes). Sediment near 2 of these 34 outfalls (Outfalls 2004 and 2157) was determined to not be sampleable based on their locations (under large docks). Sediment near 9 of these 34 outfalls was determined not likely to be sampleable because of riprap/rocky substrate (Leidos 2014a), although sediment near 1 of these outfalls may be sampleable by foot at a lower tide (SAIC 2011). Sediment at the SCS Refd Services outfall was determined not to be sampleable due to both overwater structures and riprap. Therefore, sediment near 11 of the 34 remaining outfalls is not considered sampleable. The area near a South Park Marina outfall was eliminated because it is adjacent to a cleanup site.

The remaining 22 outfalls are targeted for sampling (Map 4-~~57~~). Either one or two samples will be collected from the vicinity (50 or 100 ft, depending on outfall diameter) of each outfall. The number of samples specified per outfall is dependent on the number of existing surface sediment locations within, or close to, the 50- or 100-ft radius. Based on these criteria, a total of 24 surface sediment samples are targeted (Table 4-~~36~~). This sampling design will not generally result in adjacent, upstream, and downstream samples within the 50- or 100-ft radius at each outfall (the original Ecology goal). However, because sampling near these outfalls is difficult (as noted based on earlier sampling attempts³¹), Ecology has deemed this design sufficient to fill remaining data gaps. Section 4.2.2.~~23~~ provides information on field contingencies.

Per the Work Plan (Windward and Integral 2017b), all near-outfall sediment samples will be analyzed for the analytes listed in ROD Table 20. Dioxins/furans will also be analyzed in samples collected near Outfalls 2226, T107 Park, 2507, Seattle Dist Ctr, 5th Ave South, CleanScapes B, and 2100A, based on existing surface sediment data (Map 4-6). Archives will be kept of all near-outfall samples. Archived samples will be analyzed for dioxins/furans, unless existing information indicates or suggests dioxins/furans data are not needed at a given location.³² Data considered in these decisions will include all existing data and surface sediment data collected pursuant to this QAPP. EPA and Ecology will be consulted prior to finalizing which additional near-outfall sediment samples will be analyzed for dioxins/furans.

³¹ Ecology has previously attempted to collect three samples near each outfall: adjacent to, upstream, and downstream of the direction of flow from the outfall (Leidos 2014a).

³² Pursuant to Ecology's source control strategy, use of the remedial action level (RAL) is sufficient for source control for constituents without SMS (e.g., dioxins/furans) (Ecology 2016).

4.1.23.2 Bank soil sampling

Uncharacterized exposed bank areas between +4 and +12 ft MLLW³³ will also be sampled to assist Ecology in source control.

In 2016, Leidos produced maps for Ecology delineating exposed bank areas on the LDW that had not been characterized (LDWG 2016). This delineation was based on areas identified as exposed bank in the LDW FS (AECOM 2012), and on bank locations sampled in 2011 by Hart Crowser for Ecology (Hart Crowser 2012). Based on its assessment, Leidos identified 10 exposed banks that had not been characterized (LDWG 2016) (Map 4-78).

Uncharacterized exposed bank areas from the Leidos list were further screened relative to the criteria outlined in Figure 4-2. In addition, the location of the bank area relative to that of preliminary dredge/cap areas (as identified in ROD Figure 18 (EPA 2014b)) was considered in this assessment, although none of the banks were excluded based on this consideration.

³³ This elevation is approximately equal to MHHW. NOAA reports MHHW at the Seattle station (Elliott Bay) as +11.36 ft MLLW (NOAA 2013).

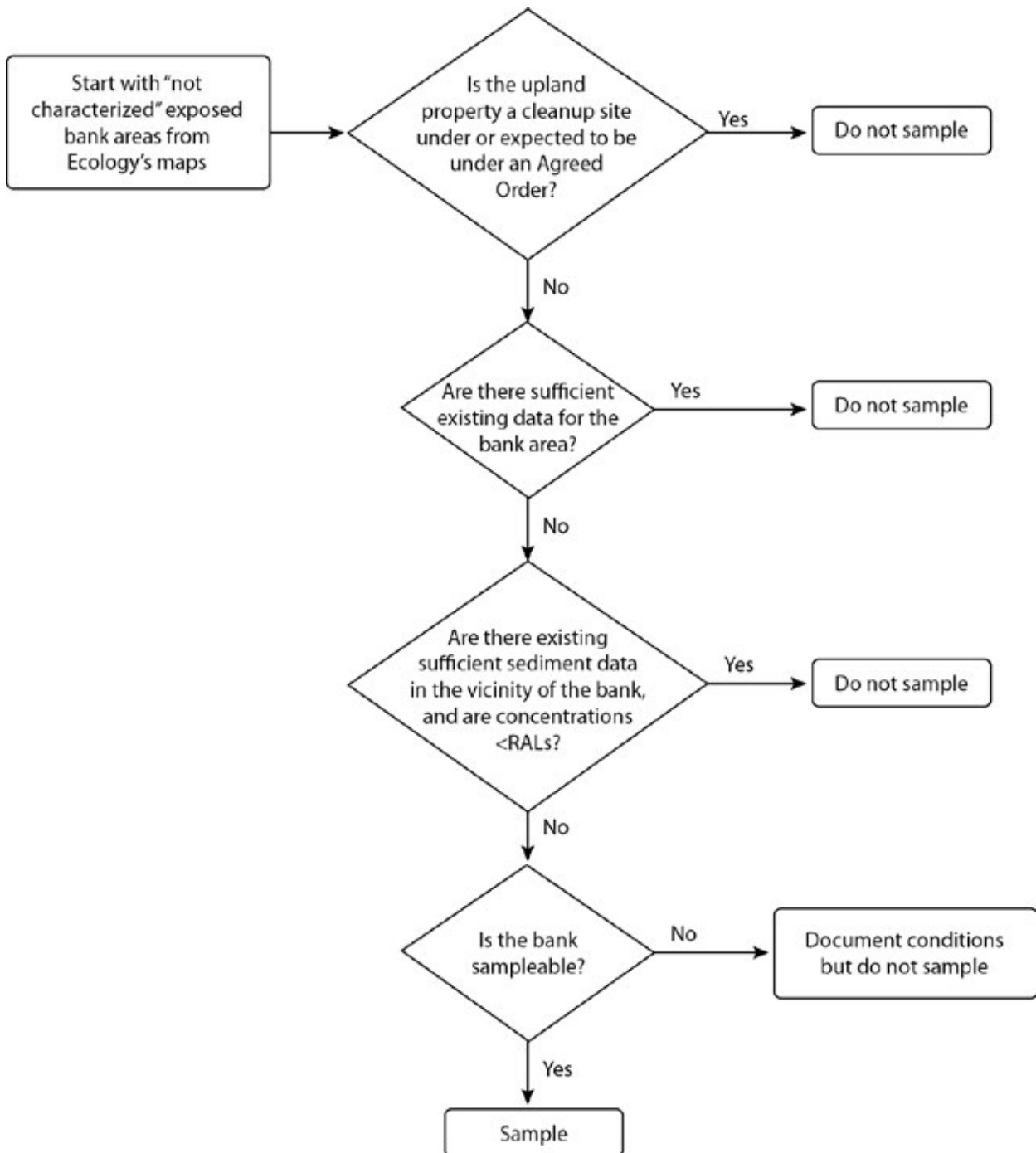


Figure 4-2. Selection criteria for sampling banks

Three of the 10 areas (RM 0.1 W, RM 4.2 to RM 4.3 W, and RM 4.8 to RM 5.0 E) were determined to be sufficiently characterized based on the existing bank and sediment sampling data (see Table 4-47 and Map 4-78). The seven remaining uncharacterized areas were then assessed in a field reconnaissance survey conducted by boat on August 31 and September 1, 2017, to determine whether the locations could be

sampled. Substrate conditions, the presence and condition of over-water structures (which can create unsafe sampling conditions), and the presence of armoring were observed to the extent possible (Appendix E). One of the seven areas (RM 4.7 E) was observed to have a steep slope with dense vegetation and riprap; this area ~~is~~ was not considered sampleable. ~~Of t~~The other six areas, are considered sampleable one area was subsequently determined to not need sampling based on input from Ecology. One additional bank area not assessed in the field reconnaissance survey was added in order to support Ecology's source control efforts. These areas ~~and~~ will be targeted for bank soil sampling (see Table 4-~~47~~ and Map 4-~~98~~).

Table 4-47. Evaluation of exposed bank areas

"Not Characterized" Exposed Bank Area ^a (RM)	Cleanup site under or expected to be under an Agreed Order?	Are there sufficient existing data for the bank area and nearby sediment?	What data exist?	Is the bank sampleable?	Sample?	Rationale for Exclusion
0.1 W	no	yes (sediment within narrow slough)	3 nearby sediment samples analyzed for COCs; no RAL exceedances	na ^b	no	sufficient nearby sediment data in narrow slough
<u>0.5–0.6 W^c</u>	<u>no</u>	<u>no</u>	<u>no data</u>	<u>na^b</u>	<u>yes</u>	<u>-</u>
0.6–0.7 E	no	no	no data	yes	yes no	<u>coordination with Ecology</u>
0.9–1.0 W	no	no	no data	yes	yes	-
2.0–2.2 W	no	no	no data	yes	yes	-
2.5–2.7 W	no	no	no data	yes	yes	-
3.0–3.1 W	no	no	no data	yes	yes	-
4.2–4.3 W	no	yes (sediment/bank)	1 nearby bank/sediment sample analyzed for COCs; no RAL exceedances	yes	no	sufficient nearby sediment/bank data
4.6–5.0 W	no	no	no data	yes	yes	-
4.7 E	no	no	no data	no	no	not sampleable
4.8–5.0 E	no	yes (sediment/bank)	9 nearby sediment sample locations, 4 of which were analyzed for PCBs only. There have been 8 exceedances for total PCBs and 1 exceedance for 1,4-dichlorobenzene	na ^b	no	sufficient nearby sediment/bank data

^a Based on Leidos's maps for Ecology.

^b Banks were not surveyed in the reconnaissance survey.

^c Bank area designated "characterized" on Leidos's maps for Ecology and added to analysis based on input from Ecology.

COC – contaminant of concern

Ecology – Washington State Department of Ecology

na – not available

PCB – polychlorinated biphenyl

RAL – remedial action level

RM – river mile

A total of 11 composite-discrete samples will be collected from the 6 banks, per Ecology direction (Table 4-58). The number of composite samples for each bank area is proportional to the size of the bank area. Each bank will have at least one composite discrete sample (Table 4-5). each composite sample will include three samples that are spatially balanced across the bank area, to the extent possible, and collected across variable heights. Bank areas longer than 650 linear ft will have at least one composite sample per 650 linear ft (Table 4-8). Additionally, in bank areas encompassing more than one upland property (i.e., Bank Areas 4 and 6), samples will be collected so that composites are not comprised of samples taken from across property boundaries. However, due to the small property sizes, this will not be possible for the southern sample location in Bank Area 4. Specific locations may be sampled at more than one elevation based on field and tidal conditions, substrate material, bank slope, and exposed bank area. The number of elevations sampled will be determined during the field effort based on these considerations and past examples (Hart Crowser 2012), with potential oversight from Ecology.

Table 4-58. Number of proposed discrete~~composite~~ samples per bank

Bank	Exposed Bank Area (approximate RM)	Proposed Number of <u>Composite-Discrete</u> Samples
1	0.65–0.76 WE	1
2	0.9–1.0 W	1
3	2.0–2.2 W	3
4	2.5–2.7 W	23
5	3.0–3.1 W	1
6	4.6–5.0 W	62
Total	-	44 ^a

^a Additional samples may be collected if it is determined during the field effort that additional elevations are needed.

RM – river mile

Furthermore, an additional-separate, discrete sample will be collected at any location in the bank areas that appears to represent a unique potential source (i.e., area with discoloration or visible seepage of material). Such samples will be collected in addition to the 14 composite-discrete samples noted in Table 4-58.

Per the Work Plan (Windward and Integral 2017b), all bank sediment samples will be analyzed for the analytes listed in ROD Table 20. Dioxins/furans will also be analyzed in the sample(s) collected at Bank Area 2, based on existing surface sediment data (Map 4-6). Archives will be kept of all bank samples. Archived samples will be analyzed for dioxins/furans unless existing information indicates or suggests

dioxins/furans data are not needed at a given location.³⁴ Data considered in these decisions will include all existing data and surface sediment data collected pursuant to this QAPP. EPA and Ecology will be consulted prior to finalizing which additional bank samples will be analyzed for dioxins/furans.

4.1.32 Intertidal surface sediment samples (0–45 cm)

This section presents the sampling design for the intertidal 0–45-cm surface sediment samples that will be collected to evaluate DQOs 76 through 109 (Table 2-2). The design to measure conditions in the LDW-wide potential clamming areas and each of the eight beach play areas is spatially balanced and is based on composite samples. An overview is presented in Table 4-63, and details about sample sizes and how the sampling locations were selected for each DQO are presented in the subsections that follow.

Table 4-63. Overview of intertidal 0–45-cm surface sediment sampling approach

Design Component	Approach	
	DQOs <u>76</u> and <u>87</u> – Potential Clamming Area 95UCL and Mean	DQO <u>98</u> and <u>109</u> – Beach Play Area 95UCLs and Means
Sample type	composite samples	composite samples
Sample sizes	3 site-wide composite samples (71 samples per composite) for a total of 213 samples	3 composite samples for each of the 8 beaches for a total of 24 composite samples; each composite sample to include 3 to 9 locations for a total of 43 locations; 3 samples collected at each of the 43 locations for a total of 129 samples
Sampling locations	71 locations site wide	3 to 9 locations per beach, 43 locations in total

95UCL – 95% upper confidence limit for the mean

DQO - data quality objective

4.1.32.1 Potential clamming area composites

The potential clamming area identified in ROD Figure 6 (EPA 2014b)³⁵ will be characterized with three site-wide composite samples, each containing sediment from 71 locations throughout the potential clamming area. These 71 locations have been distributed throughout the site-wide potential clamming area, which was divided into 16 subareas (Map 4-24).

³⁴ Pursuant to Ecology's source control strategy, use of the RAL is sufficient for source control for constituents without SMS (e.g., dioxins/furans) (Ecology 2016).

³⁵ ROD Figure 6 is titled *LDW areas with parks and habitat restoration, beach play activities, and potential clamming*.

The total number of locations (71) was determined based on the requirements that every potential clamming subarea be sampled, and that the number of sampling locations within each subarea be approximately proportional to its area. In practice, one sampling location was placed in each of the smallest potential clamming subareas, and a proportionally larger number of sampling locations was placed in each of the larger potential clamming subareas. For potential clamming subareas with more than 1 sampling location, locations were randomly located with a minimum separation of 150~~25~~ ft to obtain sufficient spatial ~~distribution~~ separation of among samples ~~within the potential clamming subareas to avoid clustering~~. This approach resulted in a total of 71 sampling locations in potential clamming area throughout the LDW (Map 4-~~94~~).

Overall, the subareas represented by each sampling location range from 0.9 to 1.8 ac across the 16 potential clamming subareas, with an average of one sample per 1.4 ac in each of the subareas (Table 4-~~74~~ and Map 4-~~94~~). The resulting data will represent an approximately spatially balanced dataset with which to assess baseline conditions in the potential clamming area throughout the LDW. In future monitoring, the sampling locations in the potential clamming subareas will be re-randomized to allow unbiased inference about potential site-wide clamming conditions at each point in time.

Table 4-~~74~~. Number of sampling locations per potential clamming subarea

Potential Clamming Sub a Area	Sub a Area (ac)	No. Sampling Locations	Area per Sampling Location (ac)
1	2.3	2	1.2
2	29	19	1.5
3	4.8	3	1.6
4	2.4	2	1.2
5	1.8	2	0.9
6	1.5	1	1.5
7	2.8	2	1.4
8	2.4	2	1.2
9	2	2	1
10	2.8	2	1.4
11	0.85	1	0.9
12	21	13	1.6
13	5.3	3	1.8
14	4.3	3	1.4
15	16	10	1.6
16	6.2	4	1.6
Total	105	71	1.4na

ac – acre

na – not applicable

At each of the 71 locations, ~~three~~ 3 separate samples will be collected in close proximity to each other for a total of 213 samples (Map 4-~~94~~ 94). Close proximity is defined as collecting ~~three~~ 3 samples within a circle centered on the location coordinates with a 5-ft radius (see Section 4.2.2.~~32~~ 32 for more details).

One of the three samples from each location will be included in one of three site-wide composite samples. In this way, each composite sample will contain 71 unique samples. The composite concentrations represent the average concentrations in the LDW-wide potential clamming area and the three composites will provide independent estimates of the LDW-wide potential clamming area average based on these 71 locations.

Based on the assumption of normality, the 95UCL will be derived with the standard equation for a normally distributed population,³⁶ and the potential clamming area-wide mean concentration will be the arithmetic average of the three site-wide composite sample concentrations.

4.1.~~32~~ 32 Beach play area composites

Each of the eight beach play areas identified in the ROD will be characterized using three composite samples. Sampling locations were randomly distributed throughout each of the eight beach play areas. The number of samples in each beach play area was determined based on the size of the beach play area.

The number of sampling locations contributing sediment to each beach play area composite ranges from three to nine per beach, with the locations spatially balanced within each beach (Map 4-~~105~~ 105). The total number of locations (43) was determined based on the requirements that the smallest beaches were assigned three locations, and that the number of sampling locations within each beach play area be approximately proportional to the physical size of each beach play area (Table 4-~~85~~ 85). The sampling locations within each beach play area were randomly located with a minimum separation of 150 ft³⁷ to avoid clustering and obtain sufficient spatial separation among samples within each beach.

Table 4-~~85~~ 85. Number of sampling locations per beach play area

Beach Play Area	Area (ac)	No. Sampling Locations	Subarea per Sampling location (ac)
1	1.5	3	0.5

³⁶ Because each analytical sample will represent the potential clamming area-wide mean based on a large number of field samples (n = 71) per composite, the Central Limit Theorem (CLT) will be invoked and normality assumed.

³⁷ The exception to this rule is at Beach Play Area 6, where the minimum distance between sampling locations is 130 ft. This smaller separation distance was necessary to accommodate a minimum of 3 sampling locations within this 1.0-ac beach.

Beach Play Area	Area (ac)	No. Sampling Locations	Subarea per Sampling location (ac)
2	2.9	3	1.0
3	5	5	1.0
4	5	5	1.0
5	11.4	9	1.3
6	1	3	0.3
7	6.1	6	1.0
8	11.1	9	1.2
Total	44	43	na

ac – acre

na – not applicable

At each location, three separate samples will be collected in close proximity to each other for a total of 129 samples across all beach play areas. One of the three samples from each location will be included in one of three beach-specific composite samples. In this way, each composite sample will represent an average for the beach-wide mean, and the three composites will be replicates of the beach-wide mean, capturing small-scale spatial variability as well as sampling and analytical error. The 95UCL for the baseline composite samples from each beach will be calculated using ~~either a t -interval ($n=3$) or~~ Chebyshev's inequality.³⁸ Each beach-wide mean will be the arithmetic average of the three beach-wide composites.

Note that some areas are common to both beach play areas and potential clamming areas. Therefore, sediment from 27 of the potential clamming area locations will also be included in beach play composite samples (Map 4-~~105~~). At these locations, sediment samples will be split; a portion of the sample will be composited in the potential clamming area composites, and a portion of the sample will be composited in the beach play area composites.

4.2 SAMPLING METHODS

Field sampling and sample identification will be performed according to the protocols described in this section. Contingencies may arise during field activities that will require modification of the general procedures outlined below. Such modifications will be at the discretion of the FC after consultation with the Windward TM and PM, the boat captain, and the EPA representative in the field, if applicable. LDWG and

³⁸ The shape of the distribution cannot be properly evaluated with only three samples, ~~so, in the data evaluation report, the results will be presented of an investigation of existing data from each beach, along with any conclusions that may be reached regarding the apparent distributional form of individual samples for each beach. For beaches with insufficient previous data or where significant skewness was found,~~ a non-parametric Chebyshev interval will be used.

EPA will be consulted if significant deviations from the sampling design are required. All modifications will be recorded in the protocol modification form (Appendix B).

4.2.1 Sample identification

Unique alphanumeric ID numbers will be assigned to each sample and recorded on the surface sediment collection form (Appendix B).

The sample IDs for individual surface sediment samples and bank samples will include the following:

- u Project area ID and two-digit year
- u Sample type:
 - u 0–10-cm samples will be SS (or SSOT for outfall samples)
 - u 0–45-cm samples will be IT45
 - u Bank soil samples will be BNK
- u Location number

For example, a surface sediment sample from location 27 would be labelled LDW18-SS-027.

Three samples will be collected at each of the potential clamming area and beach play area sampling locations (Maps 4-94 and 4-105). The three samples will be identified as a, b, and c. For example, the three samples collected at intertidal Location 8 would be LDW18-IT45-08a, LDW18-IT45-08b, and LDW18-IT45-08c.

In addition, individual samples will be combined to form composite samples, which will require composite IDs that will include the following:

- u Project area ID and two-digit year
- u Sample type:
 - u 0–10-cm composites will be SS.
 - u 0–45-cm samples will be IT45-CL for potential clamming area composites and IT45-B for beach composites.
 - u ~~Bank soil samples will be BNK.~~
- u Composite number

For example, the surface sediment composite that contains sediment from sample Locations 1, 2, 3, 4, 6, 7, and 8 would be labelled LDW18-SS-Comp01. The three potential clamming area composites samples, after combining all of the a, b, and c samples, respectively, would be LDW18-IT45-CL-Comp1, LDW18-IT45-CL-Comp2 and LDW18-IT45-CL-Comp3. The composite samples for Beach Area 3 will be

LDW18-IT45-B3-Comp1, LDW18-IT45-B3-Comp2 and LDW18-IT45-B3-Comp3. ~~The first composite bank soil sample from Bank Area 3 will be LDW18-BNK3-Comp1.~~

For the porewater samples, the sample ID will include the following:

- Project area ID and two-digit year
- PWPS (porewater passive sampler results)
- Surface sediment location ID

For example, the passive sampler associated with surface sediment Location 18 would be labelled LDW18-PWPS-SS018. The porewater concentrations calculated from the passive sampler results would be LDW18-PW-SS018.

All relevant information for each sample—including sample ID, sample date, sample time, and sample depth and location—will be recorded on the surface sediment collection form (Appendix B) and included as an appendix in the data report.

4.2.2 Surface sediment sampling methods

Surface sediment samples will be collected by boat or by land, and bank samples will be collected by land, as described in this section. For samples that will be collected by land, access agreements will be needed with property owners that are not LDWG parties and all parties (including tenants of LDWG parties) will be notified well in advance of sampling to coordinate access. The access agreement process will commence soon after the draft QAPP is submitted to EPA. In the event that LDWG and EPA cannot obtain access, alternative locations will be determined in consultation with EPA.

4.2.2.1 0–10-cm samples

Surface sediment grab sample collection and processing will follow standardized procedures for the Puget Sound area that have been developed by the Puget Sound Estuary Program (PSEP) (1997). Surface sediments will be collected from each location shown in Table 4-9³⁹ and on Map 4-1 using a pneumatic grab sampler from a sampling vessel, if feasible. In the event that a sample cannot be obtained at the target coordinates due to an obstruction or because the location is too shallow to sample by boat, the field crew will move the sample location—as little as possible and to an area that is as similar as possible in depth and character to the intended sampling location—to avoid the obstruction or enable sampling by boat. If the sample location needs to be moved more than 20-30 ft, EPA and LDWG will be consulted. To minimize the need to move the sample location, the field crew will notify property owners with barges ahead of the sampling event and will sample shallow areas during the highest tides during the field event.

³⁹ See Table 4-2 for locations where samples will be split.

Table 4-9. Surface sediment sampling location target coordinates for baseline 0–10-cm samples

Location ID	X	Y	Longitude	Latitude	River Mile	Estimated Depth Above or Below MLLW (ft)
1	1265898	211122	-122.350534	47.568659	0.0	-31
2	1266308	211198	-122.348881	47.56889	0.0	-16
3	1266484	211200	-122.348169	47.568907	0.1	na
4	1266936	211157	-122.346335	47.568812	0.1	-33
5	1266930	210796	-122.34633	47.567823	0.2	-34
6	1266734	210776	-122.347124	47.567756	0.2	-35
7	1266368	210935	-122.348618	47.568172	0.1	-39
8	1266096	211048	-122.349729	47.568469	0.1	-39
9	1266122	210482	-122.349577	47.566919	0.2	-16
10	1266461	210656	-122.348217	47.567413	0.2	-48
11	1266745	210519	-122.347058	47.567054	0.2	-40
12	1267024	210662	-122.34594	47.567459	0.2	na
13	1266875	210133	-122.346499	47.566001	0.3	-32
14	1266466	210010	-122.348145	47.565642	0.3	-41
15	1266201	210156	-122.349231	47.566029	0.2	-15
16	1266232	209905	-122.349086	47.565342	0.3	-11
17	1266644	209847	-122.347414	47.565205	0.3	-42
18	1266889	209622	-122.346404	47.564603	0.4	-15
19	1266319	209596	-122.348709	47.564501	0.3	-34
20	1266847	209464	-122.34656	47.564167	0.4	-26
21	1266550	209331	-122.347753	47.563786	0.4	-39
22	1266747	209089	-122.346936	47.563133	0.5	-35
23	1266363	208911	-122.348474	47.562624	0.5	na
24	1266579	208918	-122.347602	47.562654	0.5	-30
25	1267134	208764	-122.345343	47.562263	0.5	-19
26	1267024	208491	-122.345764	47.561509	0.6	-29
27	1266802	208602	-122.346675	47.561801	0.5	-34
28	1266329	208526	-122.348584	47.561567	0.5	-29
29	1266042	208466	-122.349739	47.561387	0.5	-14
30	1266002	208294	-122.349889	47.560915	0.6	-3
31	1266264	208148	-122.348815	47.560529	0.6	-7
32	1266644	208081	-122.347272	47.560366	0.6	-9
33	1267052	208140	-122.345624	47.560549	0.6	-36

Table 4-9. Surface sediment sampling location target coordinates for baseline 0–10-cm samples

Location ID	X	Y	Longitude	Latitude	River Mile	Estimated Depth Above or Below MLLW (ft)
34	1267214	208118	-122.344965	47.560498	0.7	-16
35	1267256	207737	-122.344764	47.559456	0.7	-30
36	1266974	207912	-122.345923	47.559921	0.7	-25
37	1266553	207785	-122.347617	47.559549	0.7	na
38	1266280	207918	-122.348734	47.559899	0.6	2
39	1266162	207665	-122.349189	47.5592	0.7	-2
40	1266004	207450	-122.349814	47.558601	0.7	-1
41	1266368	207458	-122.348338	47.558642	0.7	na
42	1266895	207571	-122.346214	47.558982	0.7	-13
43	1267121	207330	-122.345282	47.558332	0.8	-19
44	1267607	207351	-122.343312	47.558415	0.8	3
45	1266041	207151	-122.349639	47.557782	0.8	-1
46	1266091	206997	-122.349426	47.557363	0.8	-1
47	1266488	206523	-122.347779	47.556085	0.9	0
48	1266751	206205	-122.346691	47.555229	1.0	-7
49	1267016	206290	-122.345624	47.555476	1.0	-30
50	1267297	206453	-122.344499	47.555939	1.0	-27
51	1266912	207202	-122.346115	47.557969	0.8	-10
52	1267110	207107	-122.345306	47.557719	0.8	-15
53	1267406	207198	-122.344117	47.557985	0.8	-34
54	1267118	206844	-122.345254	47.556999	0.9	3
55	1267692	206785	-122.342924	47.556869	0.9	-33
56	1268139	206923	-122.341128	47.557272	0.9	na
57	1268401	206659	-122.340044	47.556562	1.0	-13
58	1268244	206523	-122.340667	47.556181	1.0	-25
59	1267487	206483	-122.34373	47.556029	1.0	-31
60	1267555	206299	-122.343442	47.555531	1.0	-31
61	1267893	206373	-122.342077	47.555752	1.0	-15
62	1267652	205843	-122.343012	47.554284	1.1	-30
63	1268115	205914	-122.341143	47.554505	1.1	-16
64	1267854	205272	-122.342151	47.55273	1.2	-29
65	1268082	205536	-122.341248	47.553467	1.2	-25
66	1267894	205058	-122.341971	47.552148	1.2	na

Table 4-9. Surface sediment sampling location target coordinates for baseline 0–10-cm samples

Location ID	X	Y	Longitude	Latitude	River Mile	Estimated Depth Above or Below MLLW (ft)
67	1268140	205193	-122.340985	47.55253	1.2	-34
68	1268073	204702	-122.341217	47.55118	1.3	-24
69	1268369	204547	-122.340005	47.550771	1.4	-29
70	1268565	204399	-122.339201	47.550375	1.4	-5
71	1268176	204196	-122.340761	47.549798	1.4	-20
72	1268034	203890	-122.341312	47.548952	1.5	na
73	1268462	203887	-122.339578	47.548966	1.5	-36
74	1268695	203965	-122.338641	47.549194	1.5	-3
75	1268489	203423	-122.339432	47.547695	1.6	-35
76	1268728	203668	-122.338481	47.54838	1.5	-12
77	1268579	203250	-122.339055	47.547226	1.6	-34
78	1268935	203260	-122.337613	47.547275	1.6	na
79	1268510	202888	-122.339303	47.546231	1.7	-12
80	1269029	202885	-122.337203	47.546251	1.7	-25
81	1269420	203071	-122.335634	47.546782	1.7	-17
82	1269240	202747	-122.336338	47.545885	1.7	-13
83	1269216	202424	-122.336411	47.544997	1.8	na
84	1268686	202557	-122.338563	47.545334	1.7	-30
85	1268959	202210	-122.337431	47.544397	1.8	-27
86	1269283	202016	-122.336106	47.543884	1.9	-16
87	1269122	201791	-122.33674	47.543256	1.9	-17
88	1269507	201780	-122.335181	47.543248	1.9	-10
89	1269417	201489	-122.335521	47.542446	2.0	-13
90	1269724	201445	-122.334274	47.54234	2.0	-25
91	1269631	200964	-122.334612	47.541018	2.1	na
92	1269926	201145	-122.333436	47.541529	2.1	-25
93	1270676	201561	-122.330431	47.54271	2.1	-12
94	1270278	201326	-122.332025	47.542044	2.1	-17
95	1270077	201196	-122.332826	47.541679	2.1	-18
96	1270025	200739	-122.333001	47.540421	2.2	-12
97	1270241	201060	-122.332153	47.541314	2.1	-18
98	1270417	200365	-122.331387	47.539418	2.3	-11
99	1270602	200609	-122.330656	47.540098	2.3	-12

Table 4-9. Surface sediment sampling location target coordinates for baseline 0–10-cm samples

Location ID	X	Y	Longitude	Latitude	River Mile	Estimated Depth Above or Below MLLW (ft)
100	1270766	200063	-122.329947	47.53861	2.4	-12
101	1270882	200164	-122.329487	47.538893	2.4	-21
102	1271153	200301	-122.328401	47.539282	2.4	-8
103	1270932	199850	-122.329259	47.538033	2.4	-18
104	1271465	199584	-122.32708	47.537334	2.5	-21
105	1271190	199632	-122.328198	47.537451	2.5	-16
106	1271771	199291	-122.32582	47.536546	2.6	-15
107	1271637	199143	-122.326349	47.536134	2.6	na
108	1271805	199040	-122.325663	47.535861	2.6	-17
109	1272075	198943	-122.324563	47.535608	2.7	-18
110	1272289	198524	-122.323664	47.534472	2.8	-12
111	1272408	198862	-122.323208	47.535406	2.7	-1
112	1272495	198268	-122.32281	47.533782	2.8	-3
113	1273377	198991	-122.319296	47.535809	2.9	-10
114	1273308	198798	-122.319561	47.535275	2.9	-8
115	1272764	198446	-122.321735	47.534283	2.8	-17
116	1272726	198037	-122.321857	47.53316	2.9	na
117	1273138	198092	-122.320193	47.533332	2.9	-1
118	1273061	197783	-122.320481	47.532483	3.0	-8
119	1273404	197864	-122.3191	47.532721	3.0	-1
120	1273339	197476	-122.319332	47.531656	3.0	-1
121	1273991	197425	-122.316688	47.53155	3.1	2
122	1273879	197159	-122.31712	47.530814	3.2	-18
123	1274130	197272	-122.316114	47.531138	3.2	2
124	1274272	196754	-122.315498	47.529725	3.3	-13
125	1274746	196687	-122.313577	47.529567	3.3	-4
126	1274626	196474	-122.314046	47.528976	3.3	-10
127	1275014	196340	-122.312464	47.528629	3.4	-14
128	1274828	196306	-122.313214	47.528526	3.4	-13
129	1275208	196106	-122.311663	47.527997	3.5	-18
130	1275003	196019	-122.312484	47.527748	3.5	na
131	1275656	195800	-122.309825	47.527184	3.6	-7
132	1275797	195631	-122.309242	47.526727	3.6	-8

Table 4-9. Surface sediment sampling location target coordinates for baseline 0–10-cm samples

Location ID	X	Y	Longitude	Latitude	River Mile	Estimated Depth Above or Below MLLW (ft)
133	1275631	195313	-122.309888	47.525847	3.7	-1
134	1276003	195042	-122.308362	47.525124	3.7	-3
135	1275839	194644	-122.308996	47.524025	3.8	-6
136	1276120	194452	-122.30784	47.523514	3.8	-8
137	1275935	194525	-122.308596	47.523704	3.8	-15
138	1276137	194052	-122.30774	47.522416	3.9	-15
139	1275959	193974	-122.308456	47.522194	3.9	-1
140	1276224	193542	-122.307351	47.521024	4.0	-14
141	1275992	193564	-122.308293	47.521072	4.0	-4
142	1276531	193336	-122.306093	47.520476	4.1	2
143	1276205	193099	-122.307391	47.519809	4.1	-9
144	1276443	193101	-122.306429	47.519826	4.1	-8
145	1276137	192780	-122.307642	47.51893	4.1	na
146	1277290	192883	-122.302987	47.519274	4.2	-13
147	1276875	192673	-122.304649	47.518676	4.2	-9
148	1276648	192704	-122.30557	47.518748	4.2	-7
149	1276475	192369	-122.306243	47.51782	4.2	-13
150	1276712	192337	-122.305281	47.517746	4.3	-3
151	1276553	192135	-122.30591	47.517184	4.3	-15
152	1276733	191901	-122.305166	47.516552	4.3	-6
153	1276605	191548	-122.305655	47.515578	4.4	-6
154	1276842	191610	-122.304701	47.51576	4.4	-2
155	1276697	191198	-122.305254	47.514625	4.5	-7
156	1276962	191212	-122.304186	47.514675	4.5	1
157	1276780	190739	-122.304885	47.513371	4.6	-7
158	1276923	190811	-122.304309	47.513575	4.5	-12
159	1276938	190529	-122.30423	47.512802	4.6	-12
160	1276639	190539	-122.30544	47.512814	4.6	2
161	1277142	190006	-122.303364	47.51138	4.7	na
162	1277501	190103	-122.301917	47.511665	4.7	na
163	1277409	190229	-122.302298	47.512004	4.7	0
164	1277374	190425	-122.302456	47.512541	4.7	-6
165	1277714	190378	-122.301075	47.512428	4.8	-7

Table 4-9. Surface sediment sampling location target coordinates for baseline 0–10-cm samples

Location ID	X	Y	Longitude	Latitude	River Mile	Estimated Depth Above or Below MLLW (ft)
166	1278097	190240	-122.299515	47.512072	4.8	na
167	1278334	190209	-122.298556	47.512	4.9	na
168	1278730	189879	-122.296929	47.511114	5.0	na
169	1266890	209821	-122.346414	47.565148	0.3	-23
170	1267205	208553	-122.345038	47.561689	0.6	-7
171	1266888	208414	-122.34631	47.561291	0.6	-35
172	1265998	208009	-122.349882	47.560133	0.6	0
173	1267053	207802	-122.345593	47.559622	0.7	-29
174	1266158	207265	-122.349175	47.558102	0.7	na
175	1267252	207364	-122.344753	47.558433	0.8	-33
176	1267698	206352	-122.342866	47.555683	1.0	-33
177	1267971	203884	-122.341565	47.548933	1.5	na
178	1268747	203540	-122.338396	47.548031	1.6	-26
179	1269985	201460	-122.33322	47.542396	2.1	-14
180	1270227	200361	-122.332154	47.539397	2.2	4
181	1270186	200341	-122.332318	47.53934	2.2	na
182	1270183	200299	-122.332327	47.539225	2.2	na
183	1271056	199592	-122.328738	47.537333	2.5	na
184	1273135	197679	-122.320173	47.5322	3.0	0
185	1276034	194947	-122.308228	47.524865	3.7	-2
186	1275959	193974	-122.308456	47.522194	3.9	-1
187	1276803	190894	-122.304803	47.513796	4.5	-10
188	1278792	189794	-122.296671	47.510885	5	na

ID – identification

MLLW – mean lower low water

na – bathymetry is not available to estimate the depth

Sediment from the 0- to 10-cm depth interval represent the biologically active zone; such sediment will allow a direct comparison with sediment collected during previous surface sediment studies in the LDW. Sediment grab samples that are predominately composed of gravel will be rejected.

The surface sediment samples will be collected using a pneumatic sampler as described in the following steps:

- 1) Using a global positioning system (GPS), maneuver the sampling vessel to the sampling location.
- 2) Open the decontaminated grab sampler jaws to the deployment position.
- 3) Guide the sampler overboard until it is clear of the vessel.
- 4) Using GPS, position the sampling vessel such that the GPS receiver (located on top of the sampling frame) is within 1 to 2 m of the target sampling location.
- 5) Lower the sampler through the water column to the bottom at a speed of approximately 0.3 m/s.
- 6) Record the GPS location of the boat when the sampler reaches the bottom.
- 7) Record the water depth and time.
- 8) Retrieve the sampler, raising it at a speed of approximately 0.3 m/s.
- 9) Guide the sampler aboard the vessel and place it on the work stand on the deck, taking care to avoid jostling that might disturb the integrity of the sample.
- 10) Examine the sample using the following sediment acceptance criteria:
 - u Sample contains sediment; samples that are predominately gravel will be rejected.
 - u Sediment is not extruding from the upper face of the sampler.
 - u Overlying water is present (indicating minimal leakage).
 - u Sediment surface is relatively flat (indicating minimal disturbance or winnowing).
 - u A penetration depth of at least 11 cm has been achieved.

If these sample acceptance criteria are not met, the sample will be rejected. If an acceptable grab sample cannot be obtained in three attempts, the sampling location will be moved as close as possible to the original target location and no further than 10 m away. If it is not possible to obtain a sample at this second location, EPA will be consulted to discuss repositioning the location.

After sample acceptance, the following observations will be noted in the field logbook:

- u GPS location
- u Depth as read by the boat's depth sounder and sample collection time
- u Gross characteristics of the surficial sediment, including texture, color, biological structures, odor, and presence of debris or oily sheen
- u Gross characteristics of the vertical profile (i.e., changes in sediment characteristics and redox layer, if visible)
- u Maximum penetration depth (nearest 0.5 cm)

u Comments relative to sample quality

The sediment from the grab at each location will be transferred directly from the sampler into a pre-cleaned stainless steel bowl or cauldron, and stirred with a dedicated, clean, stainless steel spoon or spatula until texture and color homogeneity have been achieved (PSEP 1997). The required sediment volume for each sample will range from ~~16-24~~ oz. (if a location is sampled for baseline composite only) to ~~84-92~~ oz. (if a location is also sampled for RAO 3 and *ex situ* porewater investigation) (see Appendix C). Each sediment grab will collect approximately 135 oz. (4 L) of sediment.

Following homogenization, ~~jars will be filled as specified in Appendix C (Table C-4). Specifically, two-3~~ 8-oz. jars⁴⁰ will be filled at each of the 168 0-10-cm sample locations, with ~~one-1~~ jar for sediment to be used for the ~~site-wide~~ composite sample, 1 jar for archive, and 1 jar for the NOAA split sample.⁴¹~~and one jar for archive~~ Samples that will be analyzed as individual locations (DQOs 3, 4, and 5) will require additional jars, as specified in Appendix C (Table C-4). Composite samples will be prepared at ARI as described in Section 4.4.1.1. Additional jars will be filled for locations also selected for analysis as individual locations (those supporting DQOs 3, 4 and/or 5) as specified in Appendix C (Table C-4). All jars will be stored in coolers on ice ($\leq 4 \pm 2^\circ\text{C}$), and transported to the laboratory at the end of the sampling day. Excess sediment will be returned to the sampling location. For decontamination procedures between collection activities, see Section 4.3.4.

4.2.2.23 Source samples (bank and outfall)

Surface sediment samples (0–10 cm) will be collected near 22 outfalls based on the selection process discussed in Section 4.1.23.1. The sediment samples will be collected following the methods discussed in Section 4.2.2.1 for samples collected by boat. Outfall locations that are accessible by boat will be sampled during the surface sediment Sampling Event 1. Outfall locations that are best sampled from land at low tide will be hand collected⁴² in conjunction with intertidal sediment collection during Sampling Event 2.

The target outfall sediment locations are provided in Table 4-101. If a target location based on the coordinates below is not sampleable because of obstructions, or if three sampling attempts fail, then an alternate location will be identified within the target

⁴⁰ DQOs 1 and 2 require 2 8-oz. jars. A 3rd 8-oz. jar will be filled for the NOAA split sample at each of the 168 0–10-cm locations, as sample volume allows.

⁴¹ Through EPA, NOAA has requested split samples for baseline 0–10-cm surface sediment samples. NOAA will provide labelled jars and will be responsible for the handling and custody of these samples following sample collection.

⁴² Each sample will be collected by hand from the 0- to-10-cm depth, transferred to a pre-cleaned stainless steel bowl or cauldron, and homogenized. Any large non-sediment items, such as rocks, shells, wood chips, or debris, will be removed prior to homogenization.

sampling area of 50 ft (for outfalls with a diameter less than or equal to 24 in.) or 100 ft (for outfalls with diameters greater than 24 in.) of the outfall. If a sample cannot be obtained after three attempts have been made at the alternate location, then either the deepest sample collected will be retained (3 to 10 cm in depth) or LDWG and EPA will be notified that no sample could be obtained within the targeted sampling area for that outfall, and the field crew will proceed to the next sampling location. In the case of unsafe sampling conditions, including derelict overwater structures or boat traffic, the field coordinator may deem a sampling area unsafe. Sampling will stop, conditions will be recorded in the field notes, and the sampling effort will continue at the next outfall. In the case of boat traffic, the field crew will return to the outfall at another time or on another day during that sampling event to reassess accessibility, and will conduct sampling if possible.

Table 4-104. Target coordinates for near-outfall surface sediment samples

Outfall ID	Location (approximate RM)	Sample	X	Y	Longitude	Latitude
2003	0.7 E	1	1267411	207959	-122.344157	47.560072
FedCtrS	0.8 E	1	1267479	207635	-122.343854	47.559188
GlacierNW-CBP	1.7 E	1	1269290	203021	-122.336156	47.546639
GenBiodiesel	1.7 E	1	1269568	203122	-122.335038	47.54693
Seattle Dist Ctr	2.1 E	1	1270759	201529	-122.330094	47.542626
Dawn Foods	2.3 E	1	1270793	200470	-122.329871	47.539725
CleanScapes B	2.7 E	1	1272373	198901	-122.323354	47.535509
8134	0.0 W	1	1265847	211069	-122.350737	47.568512
2226	0.5 W	1	1266089	208734	-122.349571	47.562126
T107 Park	0.6 W	1	1265912	207963	-122.350225	47.560003
2507	2.1 W	1	1269590	200843	-122.334769	47.540685
2510	2.1 W	1	1269490	200552	-122.335154	47.539881
2509	2.1 W	1	1269768	200745	-122.334044	47.540426
2114	2.4 W	1	1271013	199638	-122.328916	47.537456
5th Ave S	2.5 W	1	1271195	199431	-122.328161	47.5369
2109	2.9 W	1	1272875	197873	-122.321241	47.532718
2109	2.9 W	2	1272872	197814	-122.321247	47.532558
2215	3.4 W	1	1274590	196290	-122.314177	47.528471
2101	4.0 W	1	1275923	193792	-122.308588	47.521694
2100A	4.2 W	1	1275957	192684	-122.308363	47.518659
2100A	4.2 W	2	1276056	192766	-122.30797	47.518887
Delta Marine	4.2 W	1	1276282	192344	-122.307023	47.517743

Outfall ID	Location (approximate RM)	Sample	X	Y	Longitude	Latitude
DuwSD#3	4.4 W	1	1276394	191558	-122.306511	47.515595
Ditch #2	4.9 W	1	1278276	189978	-122.298772	47.511361

ID – identification

RM – river mile

Bank samples will be collected from the six bank areas identified in Section 4.1.23.2. Each bank sample will be a discrete sample~~composite of three individual samples, each~~ collected from a depth of 0–10 cm. ~~The three individual samples for each composite sample will be equally spaced and collected from variable heights, to the extent possible. They will be collected consecutively so that the first three samples from a bank compose the first composite sample for that bank area, and so on for consecutive composites. Composites will not be composed of samples from different properties, to the extent possible.~~ Photographs will be taken of each bank area and each individual bank sample location.

The bank samples will be collected ~~using the centroid of each bank subarea and the upstream and downstream boundaries~~at the locations identified in Table 4-112. ~~As discussed above, the individual samples will be equally spaced around the centroid of each bank subarea.~~ These locations are strictly target locations. Before sampling, the field crew will survey the bank to determine which areas are sampleable. If the target locations are not sampleable, the field crew will move the sampling location to a nearby area within the same bank (and property to the extent possible).

Table 4-1¹². Target coordinates for bank samples

Bank ID	Sample Location ID	Centroid				Upstream Boundary				Downstream Boundary			
		X	Y	Longitude	Latitude	X	Y	Longitude	Latitude	X	Y	Longitude	Latitude
1	LDW18-BNK1	1265858	208162	-122.350461	47.560545	1265895	207993	-122.350296	47.560082	1265834	208329	-122.350573	47.561
2	LDW18-BNK2	1266568	206212	-122.34743	47.555237	1266796	206143	-122.346501	47.555062	1266419	206359	-122.348046	47.555633
3	LDW18-BNK3	1269498	200911	-122.335149	47.540865	1269547	200733	-122.334937	47.54038	1269515	201171	-122.3351	47.541579
3	LDW18-BNK3	1269420	200541	-122.335436	47.539847	1269596	200529	-122.334723	47.539825	1269547	200733	-122.334937	47.54038
3	LDW18-BNK3	1269632	200793	-122.334597	47.540549	1269776	200908	-122.334022	47.540872	1269596	200529	-122.334723	47.539825
4	LDW18-BNK4	1271407	199154	-122.327284	47.536152	1271530	199057	-122.326776	47.535892	1271355	199298	-122.327506	47.536544
4	LDW18-BNK4	1271647	198950	-122.326295	47.535605	1271721	198834	-122.325986	47.535292	1271530	199057	-122.326776	47.535892
4	LDW18-BNK4	1271829	198710	-122.32554	47.534956	1271905	198578	-122.325223	47.534598	1271721	198834	-122.325986	47.535292
5	LDW18-BNK5	1273213	197401	-122.319836	47.531443	1273274	197395	-122.319589	47.53143	1273169	197458	-122.320019	47.531598
6	LDW18-BNK6	1277457	190047	-122.302093	47.51151	1277493	190006	-122.301944	47.511399	1277275	189885	-122.302814	47.511054
6	LDW18-BNK6	1277560	189850	-122.30166	47.510974	1277703	190100	-122.301099	47.511666	1277398	189601	-122.302295	47.510284

Note: These are target locations only. As described above, the field crew will use discretion to target sampleable locations.

ID - identification

If the GPS does not work in a bank area, bank samples will be collected as close to the target location as possible using Map 4-89 as guidance. Sample locations will be recorded using distances from landmarks. Additional photographs will be taken as needed in order to record the sample location.

As described in Section 4.1.23.2, in addition to the ~~proposed discrete~~ composite samples, additional discrete individual samples will be collected at any location in the bank areas that appears to be a unique potential source, or at banks where samples are being collected from more than one elevation, as appropriate ~~issue~~.

Each bank sample will be collected by hand from the 0- to 10-cm depth, transferred to a pre-cleaned stainless steel bowl or cauldron, and homogenized. Any large non-sediment items, such as rocks, shells, wood chips, or debris, will be removed prior to homogenization.

Following homogenization, jars will be filled as specified in Appendix C (Table C-6). All outfall and bank samples collected to create bank composite samples will require 5216 oz. of sediment/soil from each of the three locations. Four 8-oz. jars, one 4-oz. jar, and one 16-oz. jar will be filled at each sampling location. If a location is identified for analysis using individual samples based on the unique characteristics of that location, then 48 oz. of soil will be required. All jars will be stored on ice in coolers ($\leq 4 \pm 2^{\circ}\text{C}$), and transported to the laboratory at the end of the sampling day.

4.2.2.32 0–45-cm samples (beach and potential clamming areas)

Intertidal (0–45-cm) sediment samples will be collected at low tide at each of the locations shown in Table 4-120 and on Maps 4-94 and 4-105.

Table 4-120. Intertidal sediment sampling location target coordinates for baseline 0–45-cm samples

Location ID	X	Y	Longitude	Latitude	Estimated Depth Above or Below MLLW (ft)
1	1265921	210479	47.566899	-122.350391	na
2	1265992	210245	47.566261	-122.350086	na
3	1266084	208707	47.562052	-122.34959	3
4	1266537	208324	47.561025	-122.347725	-1
5	1266188	208289	47.560911	-122.349134	-7
6	1266363	208115	47.560442	-122.348414	0
7	1266397	207906	47.559871	-122.348256	na
8	1266014	207801	47.559564	-122.3498	-2
9	1266223	207697	47.559288	-122.348945	2
10	1266467	207662	47.559206	-122.347954	na
11	1265979	207557	47.558893	-122.349922	-2

Table 4-129. Intertidal sediment sampling location target coordinates for baseline 0–45-cm samples

Location ID	X	Y	Longitude	Latitude	Estimated Depth Above or Below MLLW (ft)
12	1266711	207418	47.55855	-122.346947	na
13	1266467	207418	47.558537	-122.347935	na
14	1266084	207313	47.55823	-122.349479	4
15	1265901	207243	47.558028	-122.350213	3
16	1266153	207034	47.557469	-122.349175	0
17	1266816	206999	47.55741	-122.34649	3
18	1267060	206860	47.557041	-122.345491	2
19	1267269	206686	47.556574	-122.34463	na
20	1266223	206721	47.556613	-122.348867	0
21	1266293	206511	47.556044	-122.348568	6
22	1267211	208965	47.562819	-122.345045	7
23	1267243	208226	47.560793	-122.344856	-1
24	1267623	207269	47.558193	-122.343243	2
25	1268023	204020	47.549307	-122.341365	na
26	1267882	203737	47.548524	-122.341915	na
27	1268703	204164	47.549741	-122.338624	na
28	1268768	203722	47.548532	-122.338325	3
29	1269269	202589	47.545454	-122.336206	na
30	1269559	201180	47.541605	-122.334921	na
31	1269598	200903	47.540848	-122.334742	na
32	1270264	200370	47.539424	-122.332006	4
33	1270764	199945	47.538284	-122.329949	-2
34	1271403	199230	47.536361	-122.327306	na
35	1271831	198780	47.535148	-122.325538	na
36	1272045	199185	47.53627	-122.324703	2
37	1272378	198822	47.535293	-122.323327	-3
38	1272317	198374	47.534061	-122.323539	na
39	1273540	199282	47.536615	-122.318659	na
40	1273474	198951	47.535704	-122.318901	2
41	1273308	197924	47.532882	-122.319491	-1
42	1273207	197571	47.531908	-122.319874	1
43	1273606	197660	47.532172	-122.318264	-1
44	1273547	197333	47.531274	-122.31848	-3

Table 4-129. Intertidal sediment sampling location target coordinates for baseline 0–45-cm samples

Location ID	X	Y	Longitude	Latitude	Estimated Depth Above or Below MLLW (ft)
45	1273989	196857	47.529993	-122.316654	3
46	1274434	196997	47.530401	-122.314863	2
47	1274566	196832	47.529954	-122.314314	-1
48	1275063	196534	47.529163	-122.312281	na
49	1275659	195839	47.527289	-122.309815	-2
50	1275990	195309	47.525855	-122.308434	8
51	1275705	194946	47.524846	-122.309561	5
52	1275795	194645	47.524024	-122.309172	0
53	1276189	194547	47.523778	-122.307571	2
54	1276222	194183	47.522781	-122.307409	-2
55	1275855	193951	47.522127	-122.308874	6
56	1276487	193389	47.520618	-122.306276	1
57	1276619	192991	47.519536	-122.305709	na
58	1276821	192174	47.517306	-122.30483	-3
59	1276455	192053	47.516956	-122.306302	-2
60	1276918	191849	47.516421	-122.30441	-2
61	1276521	191820	47.51632	-122.306014	-3
62	1276455	191620	47.515768	-122.306268	0
63	1276853	191525	47.515527	-122.304648	-1
64	1276918	191330	47.514996	-122.30437	1
65	1276888	190188	47.511864	-122.304405	2
66	1277254	190021	47.511427	-122.30291	na
67	1277421	189721	47.510614	-122.302213	na
68	1277454	190221	47.511985	-122.302116	3
69	1277621	190054	47.511537	-122.30143	na
70	1277821	190254	47.512096	-122.300636	-2
71	1278054	190188	47.511925	-122.299688	na
72	1265833	210708	47.567523	-122.350766	na
73	1265890	208201	47.560652	-122.350334	na
74	1267272	208569	47.561737	-122.344768	na
75	1267420	207811	47.559668	-122.344106	2
76	1269691	200990	47.541093	-122.334372	4
77	1270139	200532	47.539861	-122.332523	na

Table 4-1²⁹. Intertidal sediment sampling location target coordinates for baseline 0–45-cm samples

Location ID	X	Y	Longitude	Latitude	Estimated Depth Above or Below MLLW (ft)
78	1271171	199445	47.536938	-122.328259	na
79	1272502	198783	47.535192	-122.322821	na
80	1272593	198658	47.534854	-122.322442	-3
81	1272483	198230	47.533676	-122.322855	3
82	1274431	196484	47.528993	-122.314835	0
83	1276363	192230	47.517435	-122.306686	na
84	1276519	191355	47.515045	-122.305986	-2
85	1276571	190649	47.513113	-122.305721	3
86	1277056	190086	47.511593	-122.303717	3
87	1278217	190057	47.511576	-122.299016	na

ID – identification

MLLW – mean lower low water

na – bathymetry data are not available to estimate the depth

At each location, three samples will be collected in close proximity to one another. If possible, the field crew will identify the three sampling locations based on a sampling radius of 5 ft from the target location (Figure 4-3). In the event that the locations shown conceptually on Figure 4-3 cannot be sampled, locations sampled will be those that are as close as possible to the targeted locations but not outside the 5-ft radius. Each of the three samples will be designated as an a, b, or c sample.

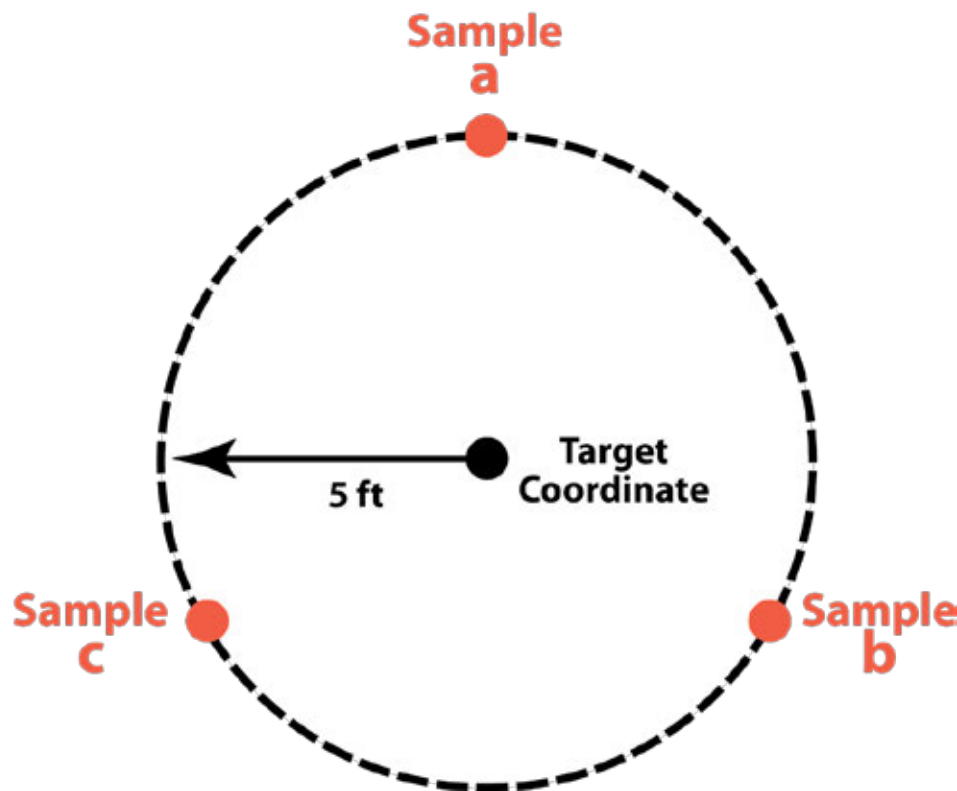


Figure 4-3. Targeted sSample locations for intertidal sediments

Each sample will be collected using a stainless steel trowel and every effort will be made to sample an equal volume throughout the 0–45-cm depth of the sample. If the target depth cannot be achieved (e.g., a rock or debris is encountered), another attempt will be made nearby within the sample area. If the target depth is not achieved after two attempts, the sample will be collected from the deepest available sediment depth, and the conditions will be documented in the field notes.

At each sampling location, the coordinates of the sampling location will be recorded and the sediment sample for that location will be homogenized. Large gravel/rocks and shell debris will be excluded from the homogenized sample to the extent practicable.

Following homogenization, jars will be filled as specified in Appendix C (Table C-5). At the 44 locations sampled for the LDW-wide potential clamming area composites only, ~~two~~ 2 8-oz. jars will be filled at each sampling location (2 jars at each a, b, and c location); sediment in one jar will be used for the site-wide composite sample, and sediment in the other jar will be archived. At the ~~16~~ a, b, and c sampling locations sampled solely for the beach play area composites, ~~one~~ 1 16-oz jar will be ~~used~~ collected for the beach play area composite,⁴³ and ~~one~~ 1 8-oz jar will be archived. At the ~~27~~ a, b,

⁴³ The extra 8 oz (for a total of 16 oz) will be required for the beach play area composites (but not for the clamming composites) because fewer samples will be composited in the beach play areas.

and c sampling locations sampled for both the LDW-wide potential clamming area composites and the beach play area composites, ~~three~~3 jars will be filled (an 8-oz. jar for the clamming composite, a 16-oz. jar for the beach play area composite, and an 8-oz. archive jar).

All jars will be stored on ice in coolers ($\leq 4 \pm 2^{\circ}\text{C}$), and transported to the laboratory at the end of the sampling day. Each of the three sediment samples collected in the vicinity of a target location will be designated as an a, b, or c sample. Composite samples will be prepared by combining all the a samples, b samples, or c samples for either a beach play area or the LDW-wide potential clamming area, as described in Section 4.4.1.2.

4.2.2.4 Sediment samples for ex situ porewater investigation

~~Sixteen~~Twenty locations have been identified for the *ex situ* porewater investigation based on the range of PCB concentrations previously reported for these locations (Table 4-~~132~~). The *ex situ* porewater exposure investigation requires 1 kg wet weight (ww) of sediment. Based on an average sediment density of 2.0 g/ml, the required sediment volume is 18-oz.

At each of the ~~2016~~ locations where sediment will be collected for the *ex situ* porewater investigation, a split sample will be collected from the homogenized sediment (Appendix C, Table C-4) and transported, on ice to ARI, for the *ex situ* porewater investigation. Sample packing, transport information, and custody procedures are described in Section 4.3, and the *ex situ* testing protocols are described in Section 4.5.

4.3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Sample custody is a critical aspect of environmental investigations. Sample possession and handling must be traceable from the time of sample collection, through laboratory and data analyses, to delivery of the sample results to the recipient. Procedures to be followed for sample handling, custody, and shipping are detailed in this section. In addition, procedures for the decontamination of equipment and disposal of field-generated waste are described.

4.3.1 Sample handling procedures

At each laboratory, a unique sample identifier (termed either project ID or laboratory ID) will be assigned to each sample. The laboratory will ensure that a sample tracking record follows each sample through all stages of laboratory processing. The sample tracking record must contain, at a minimum, the name/initials of responsible individuals performing the analyses, dates of sample extraction/preparation and analysis, and types of analyses being performed.

4.3.1.1 Sediment samples

The FC will be responsible for reviewing sediment sample information recorded on field collection forms (Appendix B), and will correct any improperly recorded

information. Sample labels will contain the project number, sampling personnel, date, time, and sample ID. A complete sample label will be affixed to each individual sample jar. Labels will be filled out as completely as possible prior to each sampling event.

Samples will be placed on ice after collection for transport to ARI, ALS, and Axys. Sample packaging and transport information is summarized in Section 4.3.3.

4.3.1.2 Porewater passive samplers

Following the ~~one-month~~28-day porewater exposure, each strip will then be wrapped in clean aluminum foil envelopes, labeled, and inserted into a resealable plastic bag with corresponding labels. All resealable bags will be placed on ice in a cooler for transport to Axys. Sample packaging, transport information, and custody procedures are described in Section 4.3. Upon receipt, Axys will store all samplers in the freezer until analysis.

4.3.2 Sample custody procedures

Samples are considered to be in custody if they are: 1) in the custodian's possession or view; 2) in a secured place (under lock) with restricted access; or 3) in a container and secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s). Custody procedures, described below, will be used for all samples throughout the collection, transportation, and analytical processes, and for all data and data documentation, whether in hard copy or electronic format. Custody procedures will be initiated during sample collection.

A chain of custody form will accompany all samples to the analytical laboratory. Each person who has custody of the samples will sign the chain of custody form and ensure that the samples are not left unattended unless properly secured. During the ~~one-month~~28-day *ex situ* porewater exposure period, sediment samples will be agitated in a secure room at ARI, and will be monitored daily by ARI staff. Minimum documentation of sample handling and custody will include:

- u Sample location, project name, and unique sample ID
- u Sample collection date and time
- u Any special notations on sample characteristics or problems
- u Name of the person who initially collected the sample
- u Date sample was sent to the laboratory
- u Shipping company name and waybill number

In the field and during the *ex situ* exposure, the FC or a designee will be responsible for all sample tracking and custody procedures. The FC will also be responsible for final sample inventory, and will maintain sample custody documentation. The FC or a designee will complete chain of custody forms prior to transporting samples. At the end

of each day, and prior to sample transfer, chain of custody entries will be made for all samples. Information on the sample labels will be checked against sample log entries, and sample tracking forms and samples will be recounted. Chain of custody forms, which will accompany all samples, will be signed at each point of transfer. Copies of all chain of custody forms will be retained and included as appendices to the data reports. Samples will be shipped in sealed coolers.

ARI, ALS, and Axys will ensure that chain of custody forms are properly signed upon receipt of the samples, and will note any questions or observations concerning sample integrity on the chain of custody forms. ARI, ALS, and Axys will contact the FC and project QA/QC coordinator immediately if discrepancies are discovered between the chain of custody forms and the sample shipment upon receipt.

4.3.3 Shipping requirements

Sediment samples will be transported directly to ARI (i.e., by field staff), composite and individual sediment samples will be shipped to ALS, and passive samplers and sediments will be transported to Axys via courier. Prior to shipping, containers with sediment samples will be wrapped in bubble wrap and securely packed inside a cooler with ice packs. Passive samplers will be wrapped in foil, placed in resalable plastic bags, and securely packed inside a cooler with ice packs. The original signed chain of custody forms will be placed in a sealed plastic bag and taped to the inside lid of the cooler. Fiber tape will be wrapped completely around the cooler. On each side of the cooler, a *This Side Up* arrow label will be attached; a *Handle with Care* label will be attached to the top of the cooler, and the cooler will be sealed with a custody seal in two locations.

The temperature inside the cooler(s) containing the sediment samples and *ex situ* samplers will be checked by the laboratory upon receipt of the samples. The laboratory will specifically note any coolers that do not contain ice packs, or that are not sufficiently cold⁴⁴ ($\leq 4 \pm 2^{\circ}\text{C}$ ($\leq 6^{\circ}\text{C}$)) upon receipt. All samples will be handled so as to prevent contamination or sample loss. Any remaining sediment samples will be disposed of upon receipt of written notification by the Windward PM. Holding times will vary by analysis and are summarized in Section 4.4.2. Passive samplers will be held until the laboratory is notified by the Windward PM.

4.3.4 Decontamination procedures

Sampling requires strict measures to prevent contamination. Sources of extraneous contamination can include sampling gear, grease from ship winches or cables, spilled

⁴⁴ As stated in validation guidance documents, sample -shipping coolers should arrive at the laboratory with an internal temperature within the advisory range of $4 \pm 2^{\circ}\text{C}$; however, due to the short transit distance and time from the site to ARI, all samples may not have reached this temperature by the time they arrive at the laboratory.

engine fuel (gasoline or diesel), engine exhaust, dust, ice chests, and ice used for cooling. All potential sources of contamination in the field will be identified by the FC, and appropriate steps will be taken to minimize or eliminate contamination. For example, during retrieval of sampling gear, the boat will be positioned, when feasible, so that engine exhaust does not fall on the deck. Ice chests will be scrubbed clean with Alconox® detergent and rinsed with distilled water after use to prevent potential cross contamination. To avoid contamination from melting ice, the wet ice will be placed in separate plastic bags.

All sediment sampling and homogenizing equipment, including the mixing bowl and stainless steel implements, will be decontaminated between sampling locations per PSEP guidelines (1997) and the following procedures:

1. Rinse with site water and wash with a scrub brush until free of sediment.
2. Wash with phosphate-free detergent.
3. Rinse with site water.
4. Rinse with distilled water.

Acid or solvent washes will not be used in the field because of safety considerations and problems associated with rinsate disposal and sample integrity, specifically:

- Use of acids or organic solvents may pose a safety hazard to the field crew.
- Disposal and spillage of acids and solvents during field activities pose an environmental concern.
- Residues of solvents and acids on sampling equipment may affect sample integrity for chemical testing.

Any sampling equipment that cannot be cleaned to the satisfaction of the FC will not be used for further sampling activities.

4.3.5 Field-generated waste disposal

Excess sediment, generated equipment rinsates, and decontamination water⁴⁵ will be returned to each sampling location after sampling has been completed for that location. All disposable sampling materials and personal protective equipment (PPE) used in sample processing, such as disposable coveralls, gloves, and paper towels, will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies will be removed from the site by sampling personnel and placed in a normal refuse container for disposal as solid waste.

⁴⁵ Because decontamination water is an Alconox®/water solution (that is phosphate-free), it can be returned to the sampling location for disposal.

4.4 LABORATORY METHODS

ARI, ALS, and Axys will meet the sample handling requirements and follow the procedures described in this section. In addition, analytical methods and data quality indicator (DQI) criteria are provided herein.

4.4.1 Laboratory sample handling

Samples will be stored initially at ARI at $\leq 4 \pm 2^{\circ}\text{C}$. Sediment compositing will be conducted in the laboratory for both the surface sediment composite samples and the intertidal sediment samples.

ARI, ALS, and Axys will preserve and store samples as described in Section 4.4.2. Once prepared, samples for Axys will be packed in coolers on ice and delivered via courier service, and samples for ALS will be shipped in coolers on ice. Archive samples will be stored, frozen, at ARI.

4.4.1.1 *Surface sediment (0–10-cm) compositing*

Surface sediment samples will be composited in the laboratory (Figure 4-4). For those samples collected for DQOs 1 and 2, the contents of the seven 8-oz. jars for the composite will be combined in a stainless steel bowl or cauldron and stirred with a clean stainless steel spoon or spatula until texture and color homogeneity have been achieved (PSEP 1997). Homogenized sediment will then be split into the appropriate sample containers as described in Appendix C, Table C-4. Excess sediment will be disposed of at the laboratory.

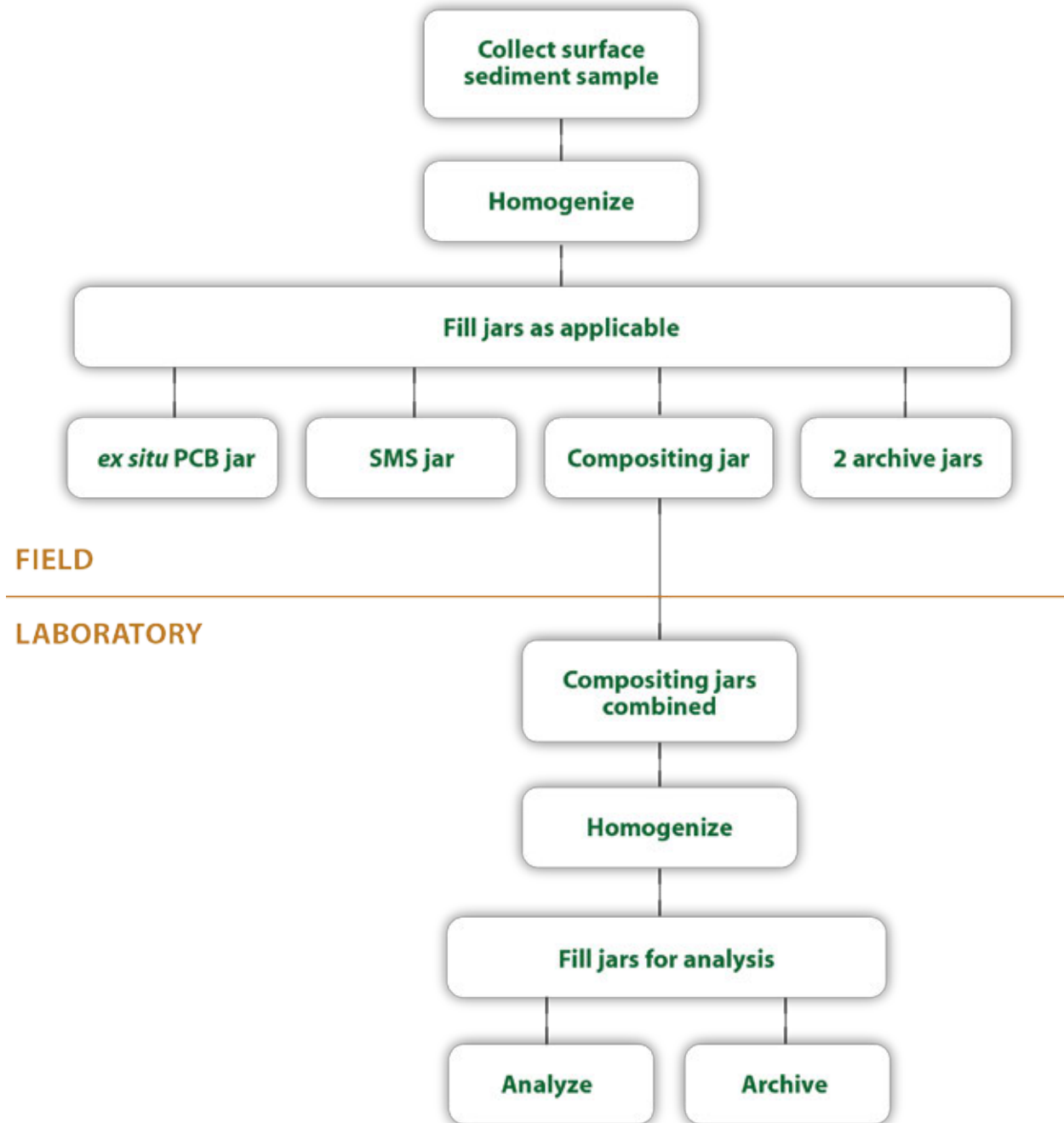


Figure 4-4. Compositing approach for 0–10-cm surface sediment samples

4.4.1.2 Intertidal sediment (0-45-cm) compositing

Intertidal 0-45-cm sediment composites will be created in the laboratory. ~~The Three~~ potential clamming area composite samples (DQOs ~~76~~ and ~~87~~) will be created as illustrated in Figure 4-5. by combining. Specifically, all of the a sediment samples from the 71 locations sediment samples will be combined in stainless steel cauldrons ~~(Figure~~

4-5). This step will be repeated for all of the b sediment samples, and then for all of the c sediment samples.

Then, each combined~~The~~ samples will be homogenized using a motorized paddle mixer. Following homogenization, the homogenized sediment will be distributed in shallow, rectangular, stainless steel containers. The homogenized sediment will then be subsampled to create the final composite sample. A stainless steel, spoon-square-edged spatula will be used to subsample the homogenized sediment to collect a minimum of 273-213 spoonfuls~~subsamples following the sediment subsampling SOP provided in Appendix D.~~~~The potential clamming area composites will be made up of 71 individual samples, and each sample will require three subsamples, resulting in a minimum of 273 spoonfuls of sediment from the homogenate to create the final composite sample.~~ Following the subsampling, the sediment will be thoroughly re-homogenized and placed in pre-cleaned, labeled, wide-mouth jars and capped with Teflon™-lined lids (Appendix C, Table C-5).

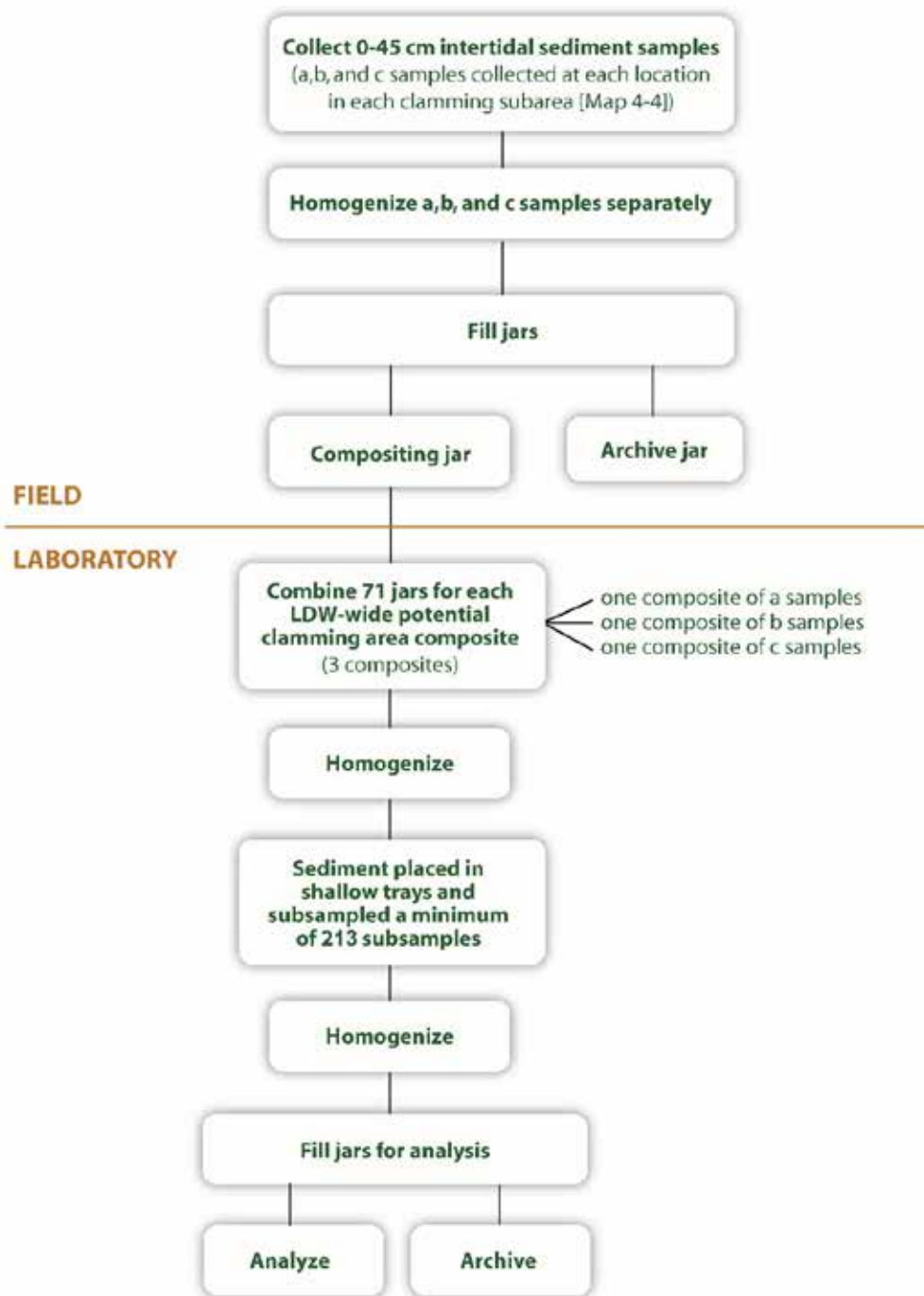


Figure 4-5. Compositing approach for 0–45-cm potential clamming area samples

The beach play area composites (DQOs [98](#) and [109](#)) will be created using sediment samples from each beach play area (the number of sediment samples will range from three to nine per beach play area, depending on beach size) (Figure 4-6). Three samples will be collected in the vicinity of each target location and designated a, b, or c samples. The composites will be created for each beach play area by combining all the a samples into one composite, all the b samples into one composite, and all the c samples into one composite.

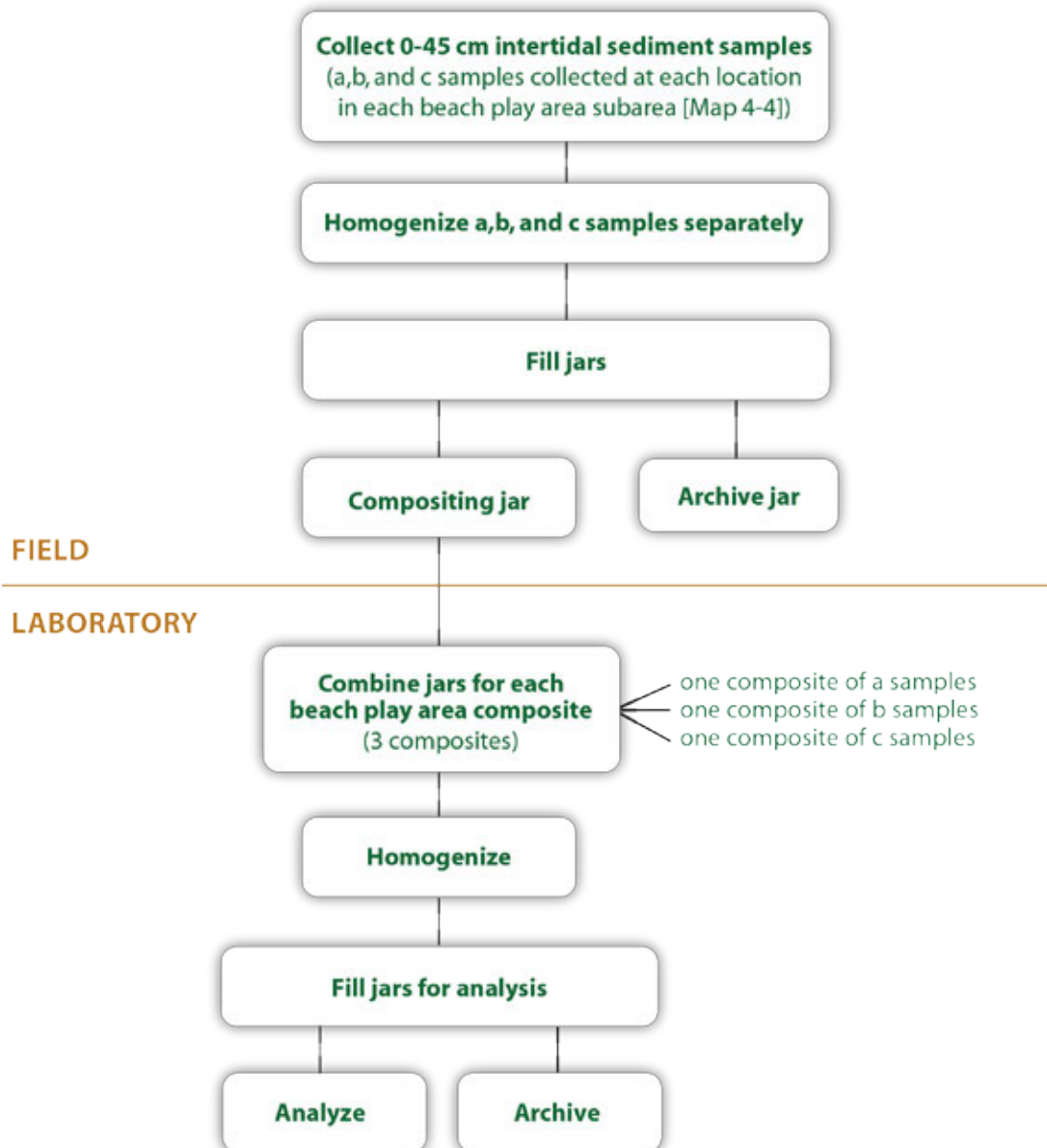


Figure 4-6.Compositing approach for beach play sediment samples

Homogenized sediment will then be split into the appropriate sample containers, as described in Appendix C, Table C-5. All sediment sample containers will be filled leaving a minimum of 1 cm of headspace to prevent breakage during shipping and storage. Excess sediment will be disposed of at the laboratory.

~~4.4.1.3 — Bank sample compositing~~

~~Bank samples will be composited in the laboratory. The contents of the three 16-oz. jars for the bank composite will be combined in a stainless steel bowl or cauldron and stirred with a clean stainless steel spoon or spatula until texture and color homogeneity have been achieved (PSEP 1997). The homogenized sample will then be split into the appropriate sample containers as described in Appendix C, Table C-7. Excess sediment will be disposed of at the laboratory.~~

4.4.2 Analytical methods

Chemical analysis of the surface sediment samples will be conducted at three different laboratories (ARI, ALS, and Axys) (Table 4-1~~34~~³⁴). Analytical methods and laboratory sample handling requirements for all measurement parameters are presented in Table 4-1~~45~~⁴⁵. The analytes for the 0-10-cm and 0-45-cm surface sediment composite samples are provided in Table 4-1~~56~~⁵⁶. The analytes for each of the ~~2306~~²³⁰⁶ individual surface sediment samples are provided in Table 4-1~~67~~⁶⁷. The analytes for the near-outfall sediment samples and the bank samples are provided in Table 4-1~~78~~⁷⁸.

Table 4-134. Sediment analyses to be conducted at each analytical laboratory

Laboratory	Analyses to be Conducted	Individual Analytes
ARI	conventionals	TOC, percent solids, grain size
	Metals	arsenic, cadmium, chromium, copper, lead, silver, zinc, mercury
	PAHs	acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene
	PCB Aroclors ^a	Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260
	SVOCs	1,2-dichlorobenzene, 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, dibenzofuran, dimethyl phthalate, hexachlorobenzene, n-nitrosodiphenylamine, PCP, and phenol
Alys	toxaphene	toxaphene
	dioxin/furan congeners	2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, 1,2,3,4,6,7,8-HpCDD, OCDD, 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, and OCDF
ALS	PCB congeners	all 209 congeners (refer to Appendix C)
	black carbon	black carbon

^a If none of the PCB Aroclors are detected, then the sample ~~will be submitted for~~ will be submitted to Alys for analysis of PCB congeners.

ALS – ALS Environmental-Kelso

ARI – Analytical Resources, Inc.

Alys – Alys Analytical Services Ltd.

HpCDD – heptachlorodibenzo-*p*-dioxin

HpCDF – heptachlorodibenzofuran

HxCDD – hexachlorodibenzo-*p*-dioxin

HxCDF – hexachlorodibenzofuran

OCDD – octachlorodibenzo-*p*-dioxin

OCDF – octachlorodibenzofuran

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

PCP – pentachlorophenol

PeCDD – pentachlorodibenzo-*p*-dioxin

PeCDF – pentachlorodibenzofuran

SVOC – semivolatile organic compound

TOC – total organic carbon

TCDD – tetrachlorodibenzo-*p*-dioxin

TCDF – tetrachlorodibenzofuran

Table 4-145. Analytical methods and sample handling requirements for surface sediment samples

Parameter ^a	Method	Reference	Extraction Solvent	Cleanup	Laboratory	Container	Preservative	Sample Holding Time
TOC	high-temperature combustion	EPA 9060	na	na	ARI	glass jar	cool to $\leq 4 \pm 2^{\circ}\text{C}$	28 days
Percent solids	drying oven	SM 2540G	na	na	ARI	glass jar	cool to $\leq 4 \pm 2^{\circ}\text{C}$	6 months
Grain size	Pipette/sieve	PSEP (1986)	na	na	ARI	plastic jar	cool to $\leq 4 \pm 2^{\circ}\text{C}$	6 months
Metals	ICP-MS	EPA 3050B EPA 6020A UCT-KED	na	na	ARI	glass jar	cool to $\leq 4 \pm 2^{\circ}\text{C}$	6 months
Mercury	CV-AFS	EPA 7471B	na	na	ARI	glass jar	cool to $\leq 4 \pm 2^{\circ}\text{C}$	28 days
PAHs	GC/MS	EPA 3550C/ EPA 8270D-SIM	DCM/acetone	silica gel	ARI	glass jar	freeze to $\leq -10^{\circ}\text{C}$	1 year to extract if frozen; 14 days until extraction if refrigerated or when thawed, 40 days after extraction; store extracts at $\leq 6^{\circ}\text{C}$ and in the dark
PCB Aroclors	GC/ECD	EPA 3550-C Mod EPA 8082A	hexane/acetone	silica gel sulfuric acid/ permanganate sulfur or acid/base partition (optional)	ARI	glass jar	freeze to $\leq -10^{\circ}\text{C}$	1 year to extract; extract within 14 days of thawing; analyze within 1 year of extraction
SVOCs	GC/MS	EPA 3550C/ EPA 8270D	DCM/acetone	GPC (optional)	ARI	glass jar	freeze to $\leq -10^{\circ}\text{C}$	1 year to extract if frozen; 14 days until extraction if refrigerated or when thawed, 40 days after extraction; store extracts at $\leq 6^{\circ}\text{C}$ and in the dark
Toxaphene	GC/ECD	EPA 3546/ EPA 8081B	hexane/acetone	GPC (optional)	ARI	glass jar	freeze to $\leq -10^{\circ}\text{C}$	1 year to extract if frozen; 14 days until extraction if refrigerated or when thawed, 40 days after extraction; store extracts at $\leq 6^{\circ}\text{C}$ and in the dark

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Table 4-145. Analytical methods and sample handling requirements for surface sediment samples

Parameter ^a	Method	Reference	Extraction Solvent	Cleanup	Laboratory	Container	Preservative	Sample Holding Time
PCB congeners	HRGC/HRMS	EPA 1668 ^{cG}	DCM Optional: Dean-Stark Soxhlet extraction with toluene, or Soxhlet extraction with 1:1 hexane:acetone	multi-layered acid/base silica, alumina, florisil	Axys	glass jar	freeze to $\leq -10^{\circ}\text{C}$	1 year until extraction, 1 year after extraction (if in the dark at $\leq -10^{\circ}\text{C}$)
Dioxins/ furans	HRGC/HRMS	EPA 1613 ^{bB}	80:20 toluene:acetone or Dean-Stark with toluene	biobead multi-layered acid/base silica, florisil, alumina, carbon/celite	Axys	glass jar	freeze to $\leq -10^{\circ}\text{C}$	store in the dark at $0-4^{\circ}\text{C}$; store extracts for up to 1 year at $\leq 10^{\circ}\text{C}$
Black carbon	infrared	Gustafsson (2001) - CTO Pretreatment/ Combustion (950°C)/ EPA 440.0	na	Na	ALS	glass jar	cool to $\leq 4 \pm 2^{\circ}\text{C}$ to $\leq 6^{\circ}\text{C}$	no established holding time; samples kept cold until drying at 105°C , which prevents potential biological action from occurring

^a Individual analytes are listed in Table 4-243.

ALS – ALS Environmental-Kelso

ARI – Analytical Resources, Inc.

Axys – Axys Analytical Services Ltd.

CTO – chemothermal oxidation

CV-AFS – cold vapor atomic fluorescence spectroscopy

DCM – dichloromethane

EPA – US Environmental Protection Agency

GC/ECD – gas chromatography/electron capture detection

GC/MS – gas chromatography/mass spectrometry

GPC – gel permeation chromatography

HRGC/HRMS – high-resolution gas chromatography/high-resolution mass spectrometry

ICP-MS – inductively coupled plasma-mass spectrometry

IR – infrared spectroscopy

na – not applicable or not available

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

PSEP – Puget Sound Estuary Program

SIM – selected ion monitoring

SM – Standard Methods

SVOC – semivolatile organic compound

TOC – total organic carbon

UCT-KED – universal cell technology-kinetic energy discrimination

Table 4-156. Analytes for composites samples (0–10-cm and 0–45-cm samples)

Sample Type	No. of Samples	PCB Aroclors, Arsenic, cPAHs, and Dioxins/Furans	Black Carbon	Toxaphene	Conventionals (TOC, Grain Size, and Total Solids)
0–10-cm surface sediment composite	24	X	X		X
0–45-cm intertidal beach play area composite	24	X		X	X
0–45-cm intertidal potential clamming area composite	3	X		X	X

cPAH – carcinogenic polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

TOC – total organic carbon

Table 4-167. Analytes for each individual sediment sample (0–10-cm samples)

Sample ID	SMS Analytes ^a	PCB Aroclors ^b	PCB Congeners ^c	Black Carbon	Conventionals (TOC, Grain Size and Total Solids)
LDW18-SS08	X	X	-	-	X
<u>LDW18-SS23</u>	X	X	-	-	X
LDW18-SS40	X	X	-	-	X
LDW18-SS52	X	X	-	-	X
LDW18-SS69	X	X	-	-	X
LDW18-SS91	X	X	-	-	X
LDW18-SS101	X	X	-	-	X
LDW18-SS130	X	X	-	-	X
LDW18-SS143	X	X	-	-	X
LDW18-SS161	X	X	-	-	X
<u>LDW18-SS169</u>	X	X	TBD ^b	X	X
<u>LDW18-SS170</u>	X	X	TBD ^b	X	X
<u>LDW18-SS171</u>	-	X	TBD ^b	X	X
<u>LDW18-SS172</u>	-	X	TBD ^b	X	X
<u>LDW18-SS173</u>	-	X	TBD ^b	X	X
<u>LDW18-SS174</u>	X	X	TBD ^b	X	X
<u>LDW18-SS175</u>	-	X	TBD ^b	X	X
<u>LDW18-SS176</u>	-	X	TBD ^b	X	X
<u>LDW18-SS177</u>	-	X	TBD ^b	X	X
<u>LDW18-SS178</u>	X	X	TBD ^b	X	X
<u>LDW18-SS179</u>	X	X	TBD ^b	X	X

Sample ID	SMS Analytes ^a	PCB Aroclors ^b	PCB Congeners ^c	Black Carbon	Conventionals (TOC, Grain Size and Total Solids)
LDW18-SS180	-	X	TBD ^b	X	X
LDW18-SS181	-	X	TBD ^b	X	X
LDW18-SS182	-	X	TBD ^b	X	X
LDW18-SS183	X	X	TBD ^b	X	X
LDW18-SS184	X	X	TBD ^b	X	X
LDW18-SS185	-	X	TBD ^b	X	X
LDW18-SS186	X	X	TBD ^b	X	X
LDW18-SS187	X	X	TBD ^b	X	X
LDW18-SS188	X	X	TBD ^b	X	X

^a SMS analytes include analytes listed in ROD Table 20 (metals, PAHs, and SVOCs, and ~~PCB Aroclors~~).

^b ~~Samples analyzed for PCB Aroclors and not the other SMS analytes.~~

^c PCB congeners will be analyzed in the 10 PCB porewater samples selected for analysis based on the PCB Aroclor results.

ID – identification

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

ROD – Record of Decision

SMS – Washington State Sediment Management Standards

SVOC – semivolatile organic compound

TBD - to be determined

TOC – total organic carbon

Table 4-178. Analytes for near-outfall and bank samples

Sample Type	No. of Samples	SMS Analytes ^a	Dioxins/Furans	Conventionals (TOC, Grain Size, and Total Solids)
Near-outfall sediment	245	X	<u>X (Outfalls 2226, T107 Park, 2507, Seattle Dist Ctr, 5th Ave South, CleanScapes B, and 2100A)</u> TBD ^b	X
Bank	4411 ^c	X	TBD <u>DX (Bank Area 2)</u> ^d	X

^a SMS analytes include analytes listed in ROD Table 20 (metals, PAHs, SVOCs, and PCB Aroclors).

^b At all other outfalls, sediment will be archived for ~~potential~~ dioxin/furan analysis per Section 4.1.2.1.

^c Additional discrete samples will be collected at any location in the bank areas that appears to be a unique potential source or from banks where samples are being collected from more than one elevation, as discussed in Section 4.1.2.2.

^d At all other bank areas, bank soil will be archived per Section 4.1.2.2.

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

ROD – Record of Decision

SVOC – semivolatile organic compound

SMS – Washington State Sediment Management Standards

~~TBD - to be determined~~

~~TEQ - toxic equivalents~~

TOC – total organic carbon

4.5 EX SITU POREWATER INVESTIGATION METHODS

This section describes the methods to be followed for the *ex situ* porewater investigation for PCBs.

4.5.1 Passive sampler preparation

Passive samplers will be prepared for exposure to the 16 sediment samples collected as discussed in Section 4.2.2.4. Ayxys will prepare the passive samplers and the exposures will be conducted at ARI.

Using methods based on those outlined by Gschwend et al. (2012), Ayxys will prepare the passive samplers by cleaning a known mass of 25- μ m-thick PE sheeting using sequential extractions with solvent (e.g., dichloromethane [DCM], methanol) (Appendix D).

The cleaned PE sheeting will be loaded with PRCs to allow non-equilibrium conditions between the PE and the sediment porewater to be quantified. The degree of equilibrium reached by the PRCs during the exposure will be used to infer the degree of equilibrium reached by the target PCB analytes. This information will be used to correct for non-equilibrium conditions as described in Section 4.5.4. The carbon-13-labelled PCBs to be used for PRCs will include ^{13}C -PCB8, ^{13}C -PCB28, ^{13}C -PCB95, ^{13}C -PCB111, ^{13}C -PCB153 and ^{13}C -PCB178. These compounds represent a range of homologs from dichlorobiphenyl (PCB8) to heptachlorobiphenyl (PCB178). The PRCs will be loaded by equilibrating the clean PE sheets with a methanol/water PRC solution in a glass container for at least seven days. Prior to delivery to ARI, the impregnated PE sheets will be submerged in ultra-clean water for three days to remove the methanol.

To accurately determine initial pre-exposure PRC concentrations, three 0.1-g PE strips will be cut from the PE sheets after the PRC loading is complete, wrapped in aluminum foil, and stored, frozen, at Ayxys. These day-zero PE strips will be analyzed along with the PE strips retrieved from the porewater exposure batch tests (Section 4.7.2.2). Pre- and post-exposure PRC concentrations will be used either to confirm that equilibrium has been reached for all PCB congeners, or to allow for the correction of non-equilibrium conditions between the PE and the sediment porewater.

The remaining clean PRC-impregnated PE sheets will be wrapped in aluminum foil and placed in a resealable plastic bag at $< 4 \pm 2^\circ\text{C}$ for shipment to ARI for use in the porewater exposures. Upon delivery, ARI will store the PE sheets in the refrigerator until the exposures are started.

4.5.2 Porewater exposure batch tests

Exposures will be conducted in accordance with design guidelines laid out by EPA et al. (2017), as detailed in Appendix D. The range of targeted PCB concentrations and TOC concentrations has been used to determine the appropriate PE sampler mass. The sampler mass must be sufficient to accumulate detectable PCB concentrations, but must not be so large as to deplete the sediment PCB concentration (i.e., less than 1% of the mass of PCBs in sediment). In the event any exposure exceeds the 1% by mass target, corrections for depletion will be made assuming a linear relationship for

partitioning characteristics of the sediment organic matter as described in Fagervold et al. (2010) and Ghosh et al. (2014).

Each sediment sample will be thoroughly homogenized, and approximately 1 kg ww of each sample will be placed in a wide-mouth glass jar with a Teflon™-lined cap. A 2-g/L sodium azide (biocide) solution will be added to each jar to achieve a well-formed slurry (80% water content) and inhibit microbial activity. A pre-weighed PRC-impregnated PE strip (0.1 g) will then be inserted into each jar. Sealed jars will be agitated in the dark on an orbital shaker table for ~~one month~~ 28 days to enhance contaminant mass transfer from the sediment porewater to the passive sampler, accelerating sampler equilibration rates. After the ~~one month~~ 28-day exposure period, the PE strips will be removed from their respective jars, rinsed with laboratory-grade deionized water, and gently wiped with clean laboratory wipes to remove any attached sediment. They will then be shipped to Axys as described in Section 4.3.3.

4.5.3 Passive sampler analysis

The PE strips will be extracted and analyzed for PCB congeners following EPA method 1668c (Table 4-145). The passive sampler handling protocols are provided in Appendix D.

The lowest possible DLs for PCB congeners in water based on the results from the PE passive samplers will be calculated using the laboratory analytical DLs for the PE strips, the partition coefficients between water and PE (from Gschwend et al. 2014), and equilibrium assumptions. Preliminary DLs calculated for each congener (assuming 100% equilibrium) are provided in Appendix C; however, these estimated DLs may be low and could be modified based on further analysis. Specifically, the more chlorinated PCB congeners may not achieve equilibrium. The actual DLs will be greater than those calculated for any PCB congener that does not reach equilibrium within the exposure period.

Chemical analyses of *ex situ* porewater samplers will be performed by Axys (Table 4-189).

Table 4-189. Analytical methods and sample handling requirements for the *ex situ* porewater passive samplers

Parameter	Method	Reference	Extraction Solvent	Cleanup	Laboratory	Container	Preservative	Sample Holding Time
PCB congeners	HRGC/HRMS	EPA 1668c	DCM	multi-layered acid/base silica, alumina, florisil	Axys	PE strip/aluminum foil	cool to ≤ 4° <u>± 2</u> °C	na

Axys – Axys Analytical Services Ltd.

DCM – dichloromethane

EPA – US Environmental Protection Agency

HRGC/HRMS – high-resolution gas chromatography/high-resolution mass spectrometry

PCB – polychlorinated biphenyl

PE – polyethylene

4.5.4 Calculation of freely dissolved PCB congener concentrations from PE concentrations

Following PCB congener analysis of the PE strips by Axys, PCB congener concentrations in the PE strips will be used to calculate the concentrations of freely dissolved PCB congeners in the sediment porewater, as summarized in Figure 4-7.

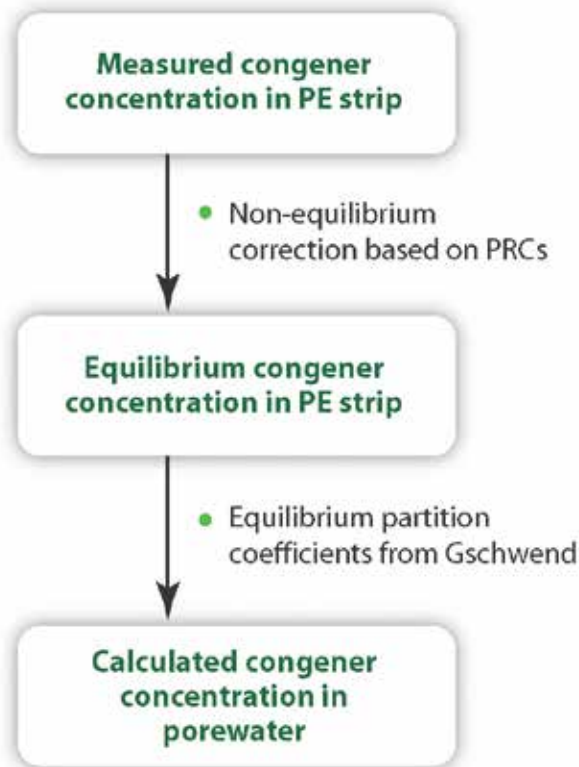


Figure 4-7. Calculation method for freely dissolved PCB congeners in porewater from passive sampler

The first step to converting the measured PE concentrations to equilibrium PE concentrations is based on the PRC concentrations in the samplers. PRC concentrations remaining in the PE sampler after the *ex situ* exposures will be used to estimate the degree of equilibrium between the sampler and the sediment porewater.

PRCs of varying hydrophobicities have been selected, because the rates of mass transfer in and out of the sampler will depend on the hydrophobic properties of each congener. Measured fractions of PRCs lost after deployment will be used to calculate a regression line between the model-estimated partitioning constant (K_D) and the octanol-water partitioning constant (K_{OW}) (Apell and Gschwend 2014). This K_{OW}/K_D fit will be used to calculate the fractional equilibration for each PCB congener using a

PRC correction calculator accessed via a graphical user interface, as described by EPA et al. (2017).

Appendix D presents the physical and chemical properties that will be used to correct for non-equilibrium conditions. PRC calculator default values will be used for the properties of the PCB congeners. If more than 90% loss is observed for a PRC, then analytes with a K_{OW} lower than or equal to this PRC will be assumed to be at equilibrium with porewater in that exposure (Gschwend et al. 2014). The equilibrium PE congener concentrations (C_{PE}) calculated using PRC data, as described above, and the default PE-to-water partition constants (K_{PEW}) provided in Gschwend et al. (2014) (Appendix D), will then be used to calculate the freely dissolved PCB concentrations in porewater (C_{PW}) using the following equation:

$$CPW = CPE / KPEW \quad \text{Equation 1}$$

4.6 ANALYTICAL DATA QUALITY OBJECTIVE AND CRITERIA

The analytical DQO for surface sediment samples and passive samplers is to develop and implement procedures that will ensure the collection of representative data of known, acceptable, and defensible quality. Parameters used to assess data quality are precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS). These parameters are discussed below, and specific DQIs are presented in Section 4.6.6.

4.6.1 Precision

Precision is the measure of reproducibility among individual measurements of the same property, usually under similar conditions, such as multiple measurements of the same sample. Precision is assessed by performing multiple analyses on a sample; it is expressed as a RPD when duplicate analyses are performed, and as a %RSD when more than two analyses are performed on the same sample (e.g., triplicates). Precision is assessed by laboratory duplicate analyses (e.g., duplicate samples, MSDs, and LCS duplicates) for all parameters. Precision measurements can be affected by the nearness of a chemical concentration to the DL, whereby the percent error (expressed as either %RSD or RPD) increases. The DQI for precision varies depending on the analyte. The equations used to express precision are as follows:

$$RPD = \frac{(\text{measured conc} - \text{measured duplicate conc})}{(\text{measured conc} + \text{measured duplicate conc})} \cdot 100 \quad \text{Equation 2a}$$

$$\%RSD = (SD/D_{ave}) \cdot 100$$

Where:

$$SD = \sqrt{\frac{\sum (D_n - D_{ave})^2}{(n - 1)}} \quad \text{Equation 2b}$$

D = sample concentration
D_{ave} = average sample concentration
n = number of samples
SD = standard deviation

4.6.2 Accuracy

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Accuracy may be expressed as a percentage recovery for MS and LCS analyses. The DQI for accuracy varies depending on the analyte. The equation used to express accuracy for spiked samples is as follows:

$$\% \text{ Recovery} = \frac{\text{spike sample results} - \text{unspiked sample results}}{\text{amount of spike added}} \times 100 \quad \text{Equation 3}$$

4.6.3 Representativeness

Representativeness is an expression of the degree to which data accurately and precisely represent an environmental condition. The sampling approach was designed to address the specific objectives described in Section 2.1. Assuming those objectives are met, the samples collected should be considered adequately representative of the environmental conditions they are intended to characterize.

4.6.4 Comparability

Comparability is an expression of the confidence with which one dataset can be evaluated in relation to another dataset. Therefore, the sample collection and chemical and physical testing will adhere to the most recent PSEP QA/QC procedures (PSEP 1997) and EPA and Standard Methods (SM) analysis protocols.

4.6.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. The equation used to calculate completeness is as follows:

$$\text{Completeness} = \frac{\text{number of valid measurements}}{\text{total number of data points planned}} \times 100 \quad \text{Equation 4}$$

The DQI for completeness for all components of this project is 90%. Data that have been qualified as estimated because the QC criteria were not met will be considered

valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

4.6.6 Sensitivity

Analytical sensitivity is the minimum concentration of an analyte above which a data user can be reasonably confident that the analyte was reliably detected and quantified. For this study, the MDL⁴⁶ or the LLOQ will be used as the measure of sensitivity for each analyte.

Tables 4-~~1920~~ lists specific DQIs for laboratory analyses of sediment samples and *ex situ* porewater samplers.

Table 4-~~1920~~. Data quality indicators for laboratory analyses

Parameter ^a	Unit	Precision ^b	Accuracy ^b		Completeness
			SRM/LCS ^c	Spiked Samples	
TOC	%	± 20%	80-120%	na	90%
Percent solids	%	± 20%	na	na	90%
Grain size	%	± 20%	na	na	90%
Metals	mg/kg dw	± 20%	80-120%	75-125%	90%
Mercury	mg/kg dw	± 20%	80-120%	75-125%	90%
PAHs	µg/kg dw	± 35%	30-160%	30-160%	90%
PCB Aroclors	µg/kg dw	± 35%	50-120%	50-120%	90%
SVOCs	µg/kg dw	± 35%	10-160%	10-160%	90%
Toxaphene	µg/kg dw	± 35%	30-160%	30-160%	90%
PCB congeners	µg/kg dw	± 20%	30-150% ^d / 60-135%	5-145% ^e	90%
Dioxins/ furans	ng/kg dw	± 20%	70-130% ^d / 63-170%	13-328% ^e	90%
Black carbon	wt%	± 20%	80-120%	na	90%

^a Individual analytes are listed in Table 4-~~243~~.

^b Values listed are performance-based limits provided by ARI, ALS, and Axys.

^c An LCS may be used to assess accuracy when SRM is unavailable. An SRM will be analyzed for PAHs, PCB Aroclors, PCB congeners, and dioxins/furans only.

^d The satisfactory acceptance limit for SRM recovery will include the uncertainty value of the CRM mean as well as the method measurement uncertainty.

^e Labelled compound percent recovery range.

ALS – ALS Environmental-Kelso

ARI – Analytical Resources, Inc.

Axys – Axys Analytical Services Ltd.

na – not applicable

PAH - polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

⁴⁶ The term MDL includes other types of DLs, such as EDL values calculated for PCB congeners and dioxin/furan congeners. Recent revisions to EPA SW846 methods no longer require the calculation of MDLs.

CRM – certified reference material
dw – dry weight
LCS – laboratory control sample

SRM – standard reference material
SVOC – semivolatile organic compound
TOC – total organic carbon

The laboratory MDL and RL values for each analytical method are compared to their respective cleanup level values in Tables 4-20~~1~~ and 4-21~~2~~. All of the analytical methods are sufficiently sensitive, with the exception of the PCB Aroclor method. For PCBs, the PCB Aroclor method (EPA 8082A) RL of 20 µg/kg dw is higher than the RAO 1 cleanup level of 2 µg/kg dw. However, PCBs in baseline sediment samples are likely to be detected at concentrations above 20 µg/kg dw, since they were detected in 94% of the 1,390 sediment samples in the FS dataset using the PCB Aroclor method. If none of the PCB Aroclors are detected in a particular composite sample, then that sample will be analyzed for PCB congeners with a method RL of 0.004 µg/kg dw.⁴⁷

Table 4-20~~1~~. RAO 1, 2, and 4 COCs and associated RLs and cleanup levels for baseline sediment samples

COC	Method	Unit	RL	Cleanup Levels		
				RAO 1	RAO 2 ^a	RAO 4
PCBs	EPA 8082A (Aroclors) ^b	µg/kg dw	20	2	500	128
	EPA 1668 cC (congeners)	µg/kg dw	0.0004 ^c 0.002 ^c			
Total arsenic	EPA 6020A	mg/kg dw	0.500	na	7	na
cPAH	EPA 8270D-SIM	µg TEQ/kg dw	4.5 ^d	na	90	na
Dioxins/furans	EPA 1613 bB	ng TEQ/kg dw	1.14 ^e	2	13	na

^a Cleanup level is minimum value for 0–10- or 0–45-cm compliance.

^b If none of the PCB Aroclors are detected in a sample, then the sample will be submitted for analysis of PCB congeners.

^c The PCB RL is based on the LMCL from Axys and represents the maximum value for an individual PCB congener. Individual congener LMCLs are listed in Appendix C. The reported LMCL will be adjusted based on the mass of each sample.

^d The RL for the cPAH TEQ value was calculated using one-half the RL for each of the cPAH compounds and the appropriate TEF values (California EPA 2009).

^e The dioxin/furan RL is based on the laboratory minimum calibration level from Axys; the dioxin/furan mammalian TEQ value was calculated using one-half the RL for each dioxin/furan compound and appropriate mammal TEF values (Van den Berg et al. 2006).

95UCL – 95% upper confidence limit for the mean

Axys – Axys Analytical Services, Ltd.

COC – contaminant of concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

dw – dry weight

EPA – US Environmental Protection Agency

LDW – Lower Duwamish Waterway

LMCL – lower method calibration limit

na – not applicable

PCB – polychlorinated biphenyl

RAO – remedial action objective

ROD – Record of Decision

RL – reporting limit

SIM – selective ion monitoring

TEF – toxic equivalency factor

TEQ – toxic equivalent

⁴⁷ The PCB RL is based on the laboratory minimum calibration level (LMCL) from Axys and represents the maximum value for an individual PCB congener. Individual congener LMCLs are listed in Appendix C. The reported LMCL will be adjusted based on the mass of each sample.

Table 4-2¹². RAO 3 COCs and associated RLs and cleanup levels for individual 0–10-cm sediment samples

COC	Method	RL	Cleanup Levels for RAO 3 ^a
Metals (mg/kg dw)			
Arsenic	EPA 6020A	0.2 500	57
Cadmium	EPA 6020A	0.1 00	5.1
Chromium	EPA 6020A	0.5 00	260
Copper	EPA 6020A	0.5 00	390
Lead	EPA 6020A	0.1 00	450
Silver	EPA 6020A	0.2 00	6.1
Zinc	EPA 6020A	4 00	410
Mercury	EPA 7471B	0.025	0.41
PAHs and SVOCs (µg/kg dw)			
Benzo(a)anthracene	EPA 8270D	20.0	2,200 ^b
Benzo(a)pyrene	EPA 8270D	20.0	1,980 ^b
Total benzofluoranthenes	EPA 8270D	40.0	4,600 ^b
Chrysene	EPA 8270D	20.0	2,200 ^b
Dibenzo(a,h)anthracene	EPA 8270D	20.0	240 ^b
Indeno(1,2,3-cd)pyrene	EPA 8270D	20.0	680 ^b
Anthracene	EPA 8270D	20.0	4,400 ^b
Acenaphthene	EPA 8270D	20.0	320 ^b
Acenaphthylene	EPA 8270D	20.0	1,320 ^b
Benzo(g,h,i)perylene	EPA 8270D	20.0	620 ^b
Fluoranthene	EPA 8270D	20.0	3,200 ^b
Fluorene	EPA 8270D	20.0	460 ^b
Naphthalene	EPA 8270D	20.0	1,980 ^b
Phenanthrene	EPA 8270D	20.0	2,000 ^b
Pyrene	EPA 8270D	20.0	20,000 ^b
Total HPAHs ^c	EPA 8270D	40.0	19,200 ^b
Total LPAHs ^d	EPA 8270D	20.0	7,400 ^b
2,4-dimethylphenol	EPA 8270D-SIM	25	29
2-methylnaphthalene	EPA 8270D	20.0	760 ^b
4-methylphenol	EPA 8270D	20.0	670
Benzoic acid	EPA 8270D	200	650
Benzyl alcohol	EPA 8270D-SIM	5	57
Bis(2-ethylhexyl)phthalate	EPA 8270D	50.0	940 ^b
Butyl benzyl phthalate	EPA 8270D	20.0	98 ^b
Dibenzofuran	EPA 8270D	20.0	300 ^b
Dimethyl phthalate	EPA 8270D	20.0	1,060 ^b
Hexachlorobenzene	EPA 8270D-SIM	5.0	7.6 ^b

Table 4-212. RAO 3 COCs and associated RLs and cleanup levels for individual 0–10-cm sediment samples

COC	Method	RL	Cleanup Levels for RAO 3 ^a
n-Nitrosodiphenylamine	EPA 8270D-SIM	5	220 ^b
PCP	EPA 8270D-SIM	20	360
Phenol	EPA 8270D	20.0	420
1,2,4-trichlorobenzene	EPA 8270D-SIM	5.00	16.2 ^b
1,2-dichlorobenzene	EPA 8270D-SIM	5.00	46.0 ^b
1,4-dichlorobenzene	EPA 8270D -SIM	5.00	62.0 ^b
PCBs (µg/kg dw)			
PCBs	EPA 8082A (Aroclors) ^{ee}	20.0	240 ^{b,c,fd}

- ^a Per the ROD (EPA 2014b), cleanup levels for RAO 3 are based on the benthic SCO chemical criteria in the SMS (WAC 173-204-562). The compliance depth is the 0–10-cm interval.
- ^b Organic carbon-normalized criteria were converted to non-normalized values using 2% TOC. Cleanup levels are assessed on organic carbon normalized basis. These values are presented as dry weight values for purposes of comparing to RLs only.
- ^c HPAH compounds include fluoranthene, pyrene, benzo(a)anthracene, chrysene, total benzo(a)fluoranthenes, benzo(a)pyrene, indeno(1,2,3 cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
- ^d LPAH compounds include naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, and 2-methylnaphthalene.
- ^{ee} If none of the PCB Aroclors are detected, then the sample will be submitted for analysis of PCB congeners by EPA Method 1668^c with an estimated RL of 0.0004-0.002 µg/kg dw. The PCB RL is based on the LMCL from Axyx and represents the maximum value for an individual PCB congener. Individual congener LMCLs are listed in Appendix C. The reported LMCL will be adjusted based on the mass of each sample.
- ^{fd} All 0–10-cm samples analyzed for PCB Aroclors will be archived for potential PCB congener analysis.
- Axyx – Axyx Analytical Services, Ltd.
COC – contaminant of concern
dw – dry weight
EPA – US Environmental Protection Agency
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LMCL – lower method calibration limit
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
- PCP – pentachlorophenol
RAO – remedial action objective
RL – reporting limit
ROD – Record of Decision
SCO – sediment cleanup objective
SIM – selective ion monitoring
SMS – Washington State Sediment Management Standards
SVOC – semivolatile organic compound
TOC – total organic carbon
WAC – Washington Administrative Code

Standard mass requirements are specified to meet RLs for each particular analytical method. Table 4-223 summarizes the sample volume needed for each sample type. The masses listed include those required for QC samples. The total jar volume required for standard analyses is 60 oz. One additional 8-oz. jar will be collected for each sample and archived.

Table 4-223. Sediment mass required per analysis

Analyte	Sediment Mass (ww)	Jar Size
TOC	6 g	4-oz. jar
Percent solids	45 g	

Analyte	Sediment Mass (ww)	Jar Size
Grain size	600 g	16-oz. jar
Metals	3 g	8-oz. jar
Mercury	1 g	
PAHs	60 g	8-oz. jar
Toxaphene	75 g	
PCB Aroclors	75 g	8-oz. jar
SVOCs	60 g	
PCB congeners	40 g	8-oz. jar
Dioxins/furan congeners	40 g	
Black carbon	30 g	8-oz. jar
<i>Ex situ</i> porewater	1 kg	16-oz. jar ^a
Archive	na	8-oz. jar

^a Two 16-oz. jars will be required for 1 kg of sediment for the *ex situ* porewater.

na – not applicable

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

SVOC – semivolatile organic compound

TOC – total organic carbon

4.7 QUALITY ASSURANCE/QUALITY CONTROL

The types of samples analyzed and the procedures conducted for QA/QC in the field and laboratory are described in this section.

4.7.1 Field quality control samples

Field QA/QC samples, such as field duplicates, are generally used to evaluate the efficiency of field decontamination procedures and the variability attributable to sample handling. A minimum of 1 field duplicate for every 20 samples will be collected for each sample type (individual 0–10-cm surface sediments, near-outfall sediments, and bank soils). In addition, one replicate *ex-situ* porewater exposure will be conducted.

4.7.2 Laboratory quality control

Before analyzing the samples, the laboratory must provide written protocols for the analytical methods to be used, calculate RLs for each analyte in each matrix of interest as applicable, and establish an initial calibration curve for all analytes. The laboratory must also demonstrate its continued proficiency by participation in inter-laboratory comparison studies, and by repeated analysis of certified reference materials, calibration checks, laboratory reagent and rinsate blanks, and spiked samples.

For the *ex situ* porewater PE samples, a LCS and a duplicate sample will be included, as detailed in the QA/QC section of Appendix D. The inclusion of these samples will

enable the evaluation of any potential contamination during laboratory procedures, and the assessment of the variability attributable to the laboratory method.

4.7.2.1 Sample delivery group

Project- and/or method-specific QC measures, such as MSs and MSDs or laboratory duplicates, will be used per sample delivery group (SDG) preparatory batch or per analytical batch, as specified in Table 4-234. A SDG is defined as no more than 20 samples, or a group of samples received at the laboratory within a 2-week period. Although a SDG may span two weeks, all holding times specific to each analytical method will be met for each sample in the SDG.

Table 4-234. Laboratory quality control sample analysis summary

Analysis Type	Initial Calibration	Initial Calibration Verification (2 nd source)	Continuing Calibration Verification	SRM or LCS ^a	Laboratory Replicates	MSs	MSDs	Method Blanks	Surrogate Spikes
TOC	na	na	na	1 per 20 samples or per batch ^b	1 per 20 samples or per batch	1 per 20 samples or per batch	na	1 per 20 samples or per batch	na
Percent solids	na	na	na	na	1 per 20 samples or per batch	na	na	na	na
Grain size	na	na	na	na	Triplicate per 20 samples	na	na	na	na
Metals	prior to analysis	after initial calibration	every 10 samples	1 per prep batch ^b	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na
Mercury	prior to analysis	after initial calibration	every 10 samples	1 per prep batch ^b	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na
PAHs	prior to analysis	after initial calibration	every 12 hours	1 per prep batch ^c	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	each sample
PCB Aroclors	prior to analysis	after initial calibration	every 10–20 analyses or 12 hours	1 per prep batch ^d	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	each sample
SVOCs	prior to analysis	after initial calibration	every 12 hours	1 per prep batch ^b	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	each sample
Toxaphene	prior to analysis	after initial calibration	every 10–20 analyses or 12 hours	1 per prep batch ^b	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	each sample
PCB congeners	prior to analysis	after initial calibration	every 12 hours	1 per prep batch ^a batch ^d	1 per prep batch	na	na	1 per prep batch	each sample
Dioxins/furans	prior to analysis	after initial calibration	every 12 hours	1 per prep batch ^a batch ^d	1 per prep batch	na	na	1 per prep batch	each sample

Analysis Type	Initial Calibration	Initial Calibration Verification (2 nd source)	Continuing Calibration Verification	SRM or LCS ^a	Laboratory Replicates	MSs	MSDs	Method Blanks	Surrogate Spikes
Black carbon	prior to analysis	after initial calibration	every 20 samples and at the end of run	3 (1 high and 2 low range) per batch or SDG	1 per batch or SDG	na	na	1 per batch or SDG	na

Note: A batch is a group of samples of the same matrix analyzed or prepared at the same time, not exceeding 20 samples.

^a An LCS may be used to assess accuracy when SRM is unavailable.

^b An LCS will be used to assess accuracy.

^c CRM172-100G will be used to assess accuracy for PAHs.

^d ~~CRM911-50G will be used to assess accuracy for PCB Aroclors.~~

^{ed} ~~NIST-1944 Puget Sound Sediment Reference Material~~ will be used to assess accuracy for PCB Aroclors, PCB congeners, and dioxins/furans.

CRM – certified reference material

LCS – laboratory control sample

MS – matrix spike

MSD – matrix spike duplicate

na – not applicable or not available

~~NIST – National Institute of Standards and Technology~~

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

SDG – sample delivery group

SRM – standard reference material

SVOC – semivolatile organic compound

TOC – total organic carbon

4.7.2.2 Laboratory quality control samples

The analyst will review the results of QC analyses from each sample group immediately after a sample group has been analyzed. The QC sample results will then be evaluated to determine whether control limits have been exceeded.

If control limits have been exceeded, then appropriate corrective action, such as recalibration followed by reprocessing of the affected samples, must be initiated before a subsequent group of samples is processed. The project QA/QC coordinator must be contacted immediately by the laboratory PM if satisfactory corrective action to achieve the DQIs outlined in this QAPP is not possible. All laboratory corrective action reports relevant to the analysis of project samples must be included in the data deliverable packages.

All primary chemical standards and standard solutions used in this project will be traceable to the National Institute of Standards and Technology (NIST), Environmental Resource Associates, National Research Council of Canada, or other documented, reliable, commercial sources. Standards will be validated to determine their accuracy by comparing them to independent standards. Laboratory QC standards are verified in a multitude of ways: second-source calibration verifications (i.e., same standard, two different vendors) are analyzed to verify initial calibrations; new working standard mixes (e.g., calibrations, spikes, etc.) are verified against the results of the original solution and must be within 10% of the true value; newly purchased standards are verified against current data. Any impurities found in the standard will be documented.

The following sections summarize the procedures that will be used to assess data quality throughout sample analysis. Table 4-2³⁴ summarizes the QC procedures to be performed by the laboratory, as well as the associated control limits for precision and accuracy.

Method Blanks

Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. A minimum of 1 method blank will be analyzed for each SDG or for every 20 samples, whichever is more frequent.

Axys has reported increased concentrations of PCB 11 in its method blank samples for the past year. The laboratory is actively working to resolve this issue and is monitoring the situation closely. In order to ensure the accuracy of the data, blank correction will be employed for PCB 11 on all samples.⁴⁸ The blank correction will be based on the mean PCB 11 concentrations in sediment laboratory method blanks for the three months preceding the analysis of the samples.

⁴⁸ If the increased concentrations of PCB 11 are resolved, then the blank correction will not be required. EPA will be consulted before any changes are made.

Standard Reference Material

SRMs are samples of similar matrices and known analyte concentrations, processed through the entire analytical procedure and used as an indicator of method accuracy. A minimum of 1 SRM will be analyzed for each SDG or for every 20 samples, whichever is more frequent. SRMs will be analyzed for PAHs, PCB Aroclors, PCB congeners, and dioxins/furans. An LCS sample can be used to assess accuracy if appropriate SRM is not available. An LCS will be analyzed for conventional and organic analyses.

Laboratory Control Samples

LCSs are prepared from a clean matrix using the same process as the project samples that are spiked with known amounts of the target compounds. The recoveries of the compounds are used as a measure of the accuracy of the test methods.

Laboratory Replicate Samples

Laboratory replicate samples provide information on the precision of the analysis, and are useful in assessing potential sample heterogeneity and matrix effects. Laboratory replicates are subsamples of the original sample that are prepared and analyzed as a separate sample, assuming sufficient sample matrix is available. A minimum of 1 laboratory replicate sample will be analyzed for each SDG or for every 20 samples, whichever is more frequent, for metals, conventional parameters, dioxins/furans, and PCB congeners. For the passive samplers, one sediment sample will be identified for replicate analysis. Two passive sampler samples will be inserted into one sample jar and analyzed as replicates.

Matrix Spikes and Matrix Spike Duplicates

The analysis of MS samples provides information on the extraction efficiency of the method on the sample matrix. By performing MSD analyses, information on the precision of the method is also provided for organic analyses. For organic analyses, a minimum of 1 MS/MSD pair will be analyzed for each SDG or for every 20 samples, whichever is more frequent, when sufficient sample volume is available, with the exception of PCB congeners and dioxins/furans. For inorganic analyses (i.e., metals), a minimum of one MS sample will be analyzed for each SDG, when sufficient sample volume is available.

Surrogate Spikes

All project samples analyzed for organic compounds will be spiked with appropriate surrogate compounds, as defined in the analytical methods. Surrogate recoveries will be reported by ARI, ALS, and Axys; however, no sample results will be corrected for recovery using these values.

Isotope Dilution Quantitation

All project samples analyzed for PCB and dioxin/furan congeners will be spiked with a known amount of surrogate compounds, as defined in the analytical methods. The

labeled surrogate compounds will respond similarly to the effects of extraction, concentration, and gas chromatography. Data will be corrected for the recovery of the surrogates used for quantification.

Internal Standard Spikes

Internal standards may be used for calibrating and quantifying organic compounds and metals using MSs. If internal standards are required by the method, all calibration, QC, and project samples will be spiked with the same concentration of the selected internal standard(s). Internal standard recoveries and retention times must be within method and/or laboratory criteria.

Performance Reference Compounds

PRCs are used to determine the degree to which passive samplers have come to equilibrium during the period of deployment. The PE strips will be loaded with carbon-13-labelled PCBs prior to deployment. The carbon-13-labelled PCBs to be used for PRCs will include ^{13}C -PCB8, ^{13}C -PCB28, ^{13}C -PCB95, ^{13}C -PCB111, ^{13}C -PCB153, and ^{13}C -PCB178. The change in PRC concentration during deployment will be used to help quantify the non-equilibrium conditions between porewater and the PE for various PCB congeners.

PRC Day-zero Blank

PE samples will be set aside and analyzed to confirm PRC concentrations. These samples will be stored, frozen, at the laboratory and analyzed with the passive sampler replicates to measure PRC concentrations. PRC concentrations in the day-zero blanks will be used to establish pre-exposure PRC concentrations, which will be necessary to determine the fraction of PRC lost from each sampler during the sediment exposures. The change in PRC concentration during the exposures will be used to quantify non-equilibrium conditions, as described in Section 4.5.4.

Passive Sampler Exposure Blank

PE samples exposure blanks will be shipped from Axys to ARI and exposed only to double-distilled water on a shaker table throughout the passive sampler exposure period. The samplers will then be shipped to Axys and analyzed in order to determine if there was any exposure to PCBs during shipping and exposure that was not associated with LDW sediment.

4.8 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Prior to each field event, measures will be taken to test, inspect, and maintain all field equipment. All equipment used, including the differential global positioning system (DGPS) unit and digital camera, will be tested for accuracy before leaving for the field event.

The FC will be responsible for overseeing the testing, inspection, and maintenance of all field equipment. The laboratory PM will be responsible for ensuring laboratory equipment testing, inspection, and maintenance requirements are met. The methods used in calibrating the analytical instrumentation are described in Section 4.9.

4.9 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Multipoint initial calibration will be performed on each analytical instrument at the start of the project, after each major interruption to the instrument, and when any continuing calibration does not meet the specified criteria. The number of points used in the initial calibration is defined in each analytical method. Continuing calibrations will be performed daily for organic analyses, every 10 samples for inorganic analyses, and with every sample batch for conventional parameters to ensure proper instrument performance.

Gel permeation chromatography (GPC) calibration verifications will be performed at least once every seven days, and corresponding raw data will be submitted by the laboratory with the data package. In addition, florasil performance checks will be performed for every florasil lot, and the resulting raw data will be submitted with the data package.

Calibration of analytical equipment used for chemical analyses includes the use of instrument blanks or continuing calibration blanks, which provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately after the continuing calibration verification, at a frequency of 1 blank for every 10 samples analyzed for inorganic analyses, and 1 blank every 12 hours for organic analyses. If the continuing calibration does not meet the specified criteria, the analysis must stop. Analysis may resume after corrective actions have been taken to meet the method specifications. All project samples analyzed by an instrument found to be out of compliance must be reanalyzed.

A Trimble® SPS461 or similar GPS receiver unit will be employed for the various sampling methods outlined in this QAPP. The GPS receiver will be calibrated daily to ensure that it is accurately recording positions from known benchmarks and functioning within the individual unit's factory specifications.

4.10 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The FC will gather and check field supplies daily for satisfactory conditions before each field event. Batteries used in the digital camera will be checked daily and recharged as necessary. Supplies and consumables for the field sampling effort will be inspected upon delivery and accepted if the condition of the supplies is satisfactory.

4.11 DATA MANAGEMENT

All field data will be recorded on field forms, which the FC will check for missing information at the end of each field day and amend as necessary. A QC check will be done to ensure that all data have been transferred accurately from the field forms to the database. Field forms will be archived in the Windward library.

ARI, ALS, and Axys are required to submit data in an electronic format, as described in Section 3.7.2. The laboratory PM will contact the project QA/QC coordinator prior to data delivery to discuss specific format requirements.

A library of routines will be used to translate typical electronic output from laboratory analytical systems, and to generate data analysis reports. The use of automated routines will ensure that all data are consistently converted to the desired data structures, and that operator time is kept to a minimum. In addition, routines and methods for quality checks will be used to ensure such translations are correctly applied.

Written documentation will be used to clarify how field and analytical laboratory duplicates and QA/QC samples were recorded in the data tables, and to provide explanations of other issues that may arise. The data management task will include keeping accurate records of field and laboratory QA/QC samples so that project team members who use the data will have appropriate documentation. All data management files will be secured on the Windward network. Data management procedures outlined in Appendix C of the Work Plan will be followed (Windward and Integral 2017b).

5 Assessment and Oversight

5.1 COMPLIANCE ASSESSMENTS AND RESPONSE ACTIONS

EPA or its designees may observe field activities during each sampling event, as needed. If situations arise wherein there is a significant inability to follow the QAPP methods precisely, the Windward PM will determine the appropriate actions and consult EPA (or its designee).

5.1.1 Compliance assessments

Laboratory and field performance assessments will consist of on-site reviews conducted by EPA of QA systems and equipment for sampling, calibration, and measurement. EPA personnel may conduct a laboratory audit prior to sample analysis. Any pertinent laboratory audit reports will be made available to the project QA/QC coordinator upon request. ARI, ALS, and Axys will be required to have written procedures addressing internal QA/QC. All laboratories and QA/QC coordinators will be required to ensure that all personnel engaged in sampling and analysis tasks have appropriate training.

5.1.2 Response actions for field sampling

The FC, or a designee, will be responsible for correcting equipment malfunctions throughout field sampling, and for resolving situations in the field that may result in nonconformance or noncompliance with this QAPP. All corrective measures will be immediately documented in the field logbook, and protocol modification forms will be completed.

5.1.3 Corrective action for laboratory analyses

ARI, ALS, and Axys will be required to comply with their current written SOPs, laboratory QA plan, and analytical methods. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data. The analysts will identify and correct any anomalies before continuing with sample analysis. The laboratory PMs will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP.

The project QA/QC coordinator will be notified immediately if any QC sample exceeds the DQIs outlined in this QAPP (Table 4-189) and the exceedance cannot be resolved through standard corrective action procedures. A description of the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, and re-extraction) will be submitted with the data package using the case narrative or corrective action form.

5.2 REPORTS TO MANAGEMENT

The FC will prepare a summary email for submittal to LDWG and EPA following each sampling day. The project QA/QC coordinator will also prepare progress reports for submittal by email to LDWG and EPA on the following occasions: 1) after sampling has been completed and samples have been submitted for analysis, 2) when information is received from the laboratory, and 3) when analyses are complete. The statuses of the samples and analyses will be indicated, with emphasis on any deviations from this QAPP. For each sampling event (Sampling Event 1 and Sampling Event 2), a data report will be written after validated data are available, as described in Section 2.2.

6 Data Validation and Usability

6.1 DATA VALIDATION

The data validation process will begin in the laboratory with the review and evaluation of data by supervisory personnel or QA specialists. The laboratory analyst will be responsible for ensuring that the analytical data are correct and complete, that appropriate procedures have been followed, and that QC results are within acceptable limits. The project QA/QC coordinator will be responsible for ensuring that all analyses performed by ARI, ALS, and Axys are correct, properly documented, and complete, and that they satisfy the project ~~DQOs~~ DQIs specified in this QAPP.

Data will not be considered final until validated. Data validation will be conducted following EPA guidance (EPA 2016a, b, 2014a; USEPA 2016).

Independent third-party data review and summary validation of the analytical chemistry data will be conducted by EcoChem⁷ or a suitable alternative. All data will undergo summary-level data validation and a minimum of 10% or one SDG will undergo full data validation. Full data validation parameters will include:

- u QC analysis frequencies
- u Analysis holding times
- u Laboratory blank contamination
- u Instrument calibration
- u Surrogate recoveries
- u LCS/SRM recoveries
- u MS recoveries
- u MS/MSD RPDs
- u Compound identifications—verification of raw data with the reported results (10% of analytes)
- u Compound quantitations—verification of calculations and RLs (10% of analytes)
- u Instrument performance check (tune) ion abundances
- u Internal standard areas and retention time shifts
- u Ion abundance ratio compared to theoretical ratios for samples analyzed by EPA methods 1613b and 1668c

If no discrepancies are found between reported results and raw data in the dataset that undergoes full data validation, then a summary validation of the rest of the data can proceed using all of the QC forms submitted in the laboratory data package. QA

review of the sediment and passive sampler chemistry data will be performed in accordance with the QA requirements of the project, the technical specifications of the analytical methods indicated in Tables 4-1~~89~~ through 4-2~~12~~, and EPA guidance for organic and inorganic data review (EPA 2016a, b). The EPA PM may have EPA peer review the third-party validation or perform data assessment/validation on a percentage of the data.

All discrepancies and requests for additional, corrected data will be discussed with ARI, ALS, and Axys prior to issuance of the formal data validation report. The project QA/QC coordinator should be informed of all contacts with ARI, ALS, and Axys during data validation. ~~P~~Review procedures used and findings made during data validation will be documented on worksheets. The data validator will prepare a data validation report that will summarize QC results, qualifiers, and possible data limitations. This data validation report will be appended to the data report. Only validated data with appropriate qualifiers will be released for general use.

6.2 RECONCILIATION WITH DATA QUALITY ~~OBJECTIVES~~INDICATORS

Data QA will be conducted by the project QA/QC coordinator in accordance with EPA guidelines (EPA 2016a, b). The results of the third-party independent review and validation will be reviewed, and cases wherein the project DQ~~I~~Os were not met will be identified. The usability of the data will be determined in terms of the magnitude of the DQ~~I~~O exceedance.

7 References

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